

DECEMBER 1961

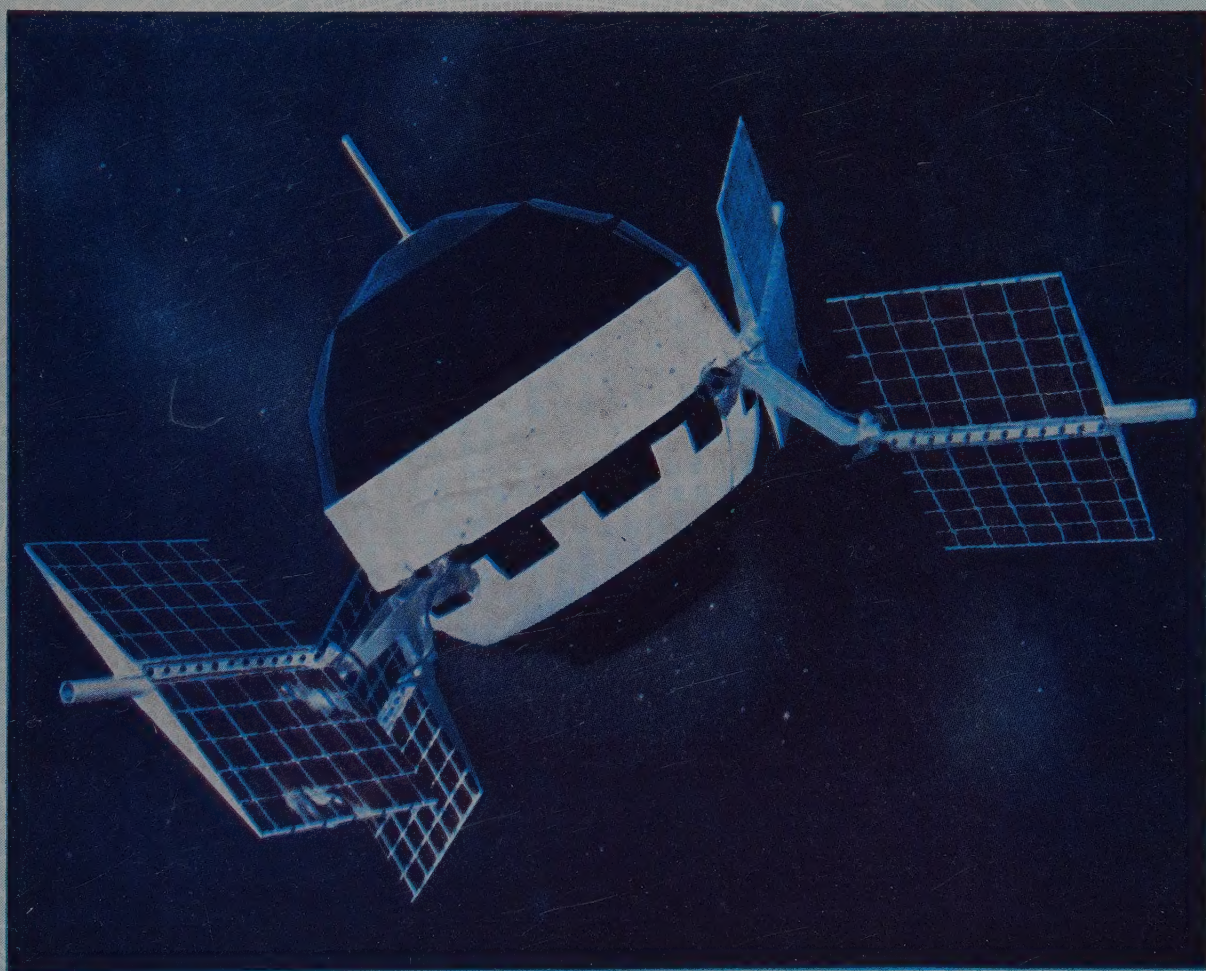
VOLUME 4 • NUMBER 12

- Hansen & Stephenson — Communications at Megamile Ranges
- Johnson — Improving the Gain Stability of Parametric Amplifiers
- Reindel — A Compact Tunable Tunnel Diode S-Band Receiver
- Bresler, Jasik & Kampinsky — A Wide Band Conical Scan Antenna Feed System
- Steele — A Very Broadband Microwave Antenna Coupler

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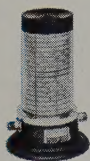
microwave journal

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Also In This Issue . . . INDEX FOR VOLUME IV

Here are seven new  coaxial instruments to simplify your microwave work and give you greater measuring flexibility in the important 1-to-4 GC frequency range. Look at the increased versatility of measurements possible with these instruments, each carrying the assurance of quality, versatility, dependability and value which make Hewlett-Packard's one of the world's most widely used lines of microwave instrumentation.



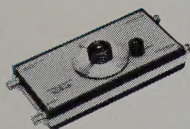
536A Coaxial Frequency Meter

For lab or production use this general-purpose frequency meter is a high resolution, broadband, direct reading instrument. Frequency is read directly in GC with high accuracy over a wide range of environmental conditions. Readability is increased by a long spiral scale calibrated in small frequency increments. The tuning plunger is spring-loaded to eliminate backlash. Smooth tuning and long life result from use of a non-contacting plunger.

Specifications

Frequency Range: 1 to 4 GC
Overall Accuracy: * $\pm 0.14\%$
Q: >1500
Connectors: Type N
Dimensions: $9\frac{1}{8}$ " high x 6" long x 6" deep. 13 pounds
Price:  536A, \$500.00

*Includes $\pm 0.02\%$ for 0-100% relative humidity and $\pm 0.0016\%/^{\circ}\text{C}$ from $13-33^{\circ}\text{C}$.

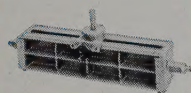


393A/394A Variable Attenuators

Accurate attenuation in high power coaxial systems is provided by these direct-reading, multi-purpose instruments, the  393A, 0.5 to 1 GC, and  394A, 1 to 2 GC. They are variable attenuators, variable directional couplers and local oscillator mixers. The direct-reading feature eliminates the need for calibration curves, and the attenuators handle up to 200 watts average, depending on line terminations. Two  908A low-power coaxial loads (furnished) permit the instruments to attenuate at levels up to 0.5 watt average power.

Specifications

Frequency Range:  393A, 0.5 to 1 GC;  394A, 1 to 2 GC
Attenuation or Coupling:  393A, 5 to 120 db,  394A, 6 to 120 db; both continuously variable
Absolute Accuracy: Within ± 1 db or 1% of dial ( 393A), ± 1.25 db or 2% of dial ( 394A), whichever is greater. (With matched generator and load)
Nominal Impedance: 50 ohms
SWR: $< 2.5:1$, 5 - 10 db attenuation; $< 1.5:1$, 10 - 30 db; $< 1.2:1$, 30 - 120 db ( 393A); $< 1.4:1$, 30 - 120 db ( 394A)
Directivity: Greater than 15 db ( 393A), or 10 db ( 394A), 10 to 40 db attenuation with loads of less than 1.05:1 SWR
Maximum Voltage: 500 v peak
Connectors: Type N
Dimensions: $5\frac{1}{2}$ " x 12" x $2\frac{3}{4}$ "
Price:  393A, \$420.00;  394A, \$420.00



872A Coaxial Slide-Screw Tuner

With the  872A Coaxial Slide-Screw Tuner, insertion of the precision probe carriage into a specially developed slab line is quickly and easily varied with a micrometer drive, and position along the line may be read directly on a recessed scale. Probe travel is at least $\frac{1}{2}$ wavelength at 0.5 GC so that any phase reflection may be compensated. Logging penetration and position of the probe makes repetition of settings simple, and the probe can be withdrawn so that no correction is applied.

Specifications

Frequency Range: 0.5 to 4 GC
Correctable SWR: 10
Insertion Loss at Max. Correctable SWR: 1 db or less
Characteristic Impedance: 50 ohms
Connectors: Type N
Dimensions: $27"$ x $6"$ x $5"$
Price:  872A, \$525.00

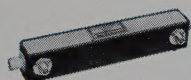


906A Coaxial Load

This sliding coaxial termination is a movable, low reflection load for terminating 50-ohm systems in their characteristic impedance. The load moves at least $\frac{1}{2}$ wavelength at its lowest rated frequency. It features a movable center conductor which insures proper seating in the mating conductor. Included are adapters for Type N connectors, plus storage case.

Specifications

Frequency Range: 1 to 12.4 GC
Load SWR: Less than 1.05
Power Rating: 1 watt
Travel: Greater than $\frac{1}{2}$ wavelength at 1 GC
Dimensions: $31"$ long. 2 lbs.
Price:  906A, \$250.00



760D/761D Dual Directional Couplers

New  760D/761D Dual Directional Couplers, two-octave vhf-uhf instruments, are especially useful for power monitoring, mixing and power sampling with tightly controlled coupling. High directivity and flat frequency response make them ideal for reflectometer systems. Power capacity is 50 watts cw and 10 kw peak.

Specifications

	Model 760D	Model 761D
Frequency Range:	250 - 1000 MC	1 - 4 GC
Mean Coupling:	$20 \pm \frac{1}{2}$ db	$20 \pm \frac{1}{2}$ db
Coupling Variation:	$\pm \frac{1}{2}$ db	$\pm \frac{1}{2}$ db
Directivity (Minimum):	35 db	30 db
Primary SWR (Maximum):	1.20	1.25
Secondary SWR (Maximum):	1.25	1.30
Connectors:	Type N	Type N
Price:	\$200.00	\$185.00



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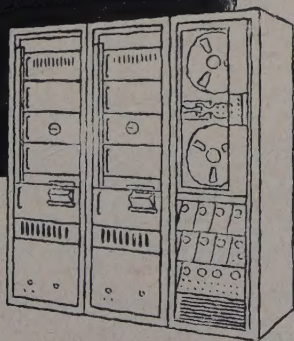
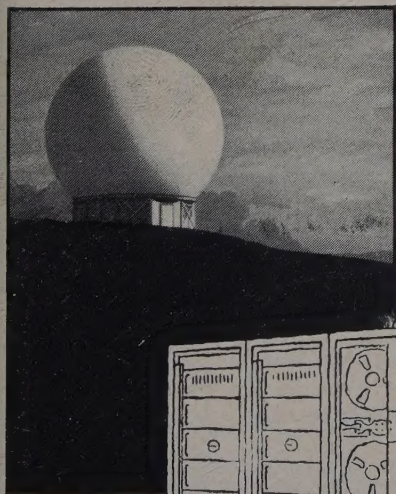
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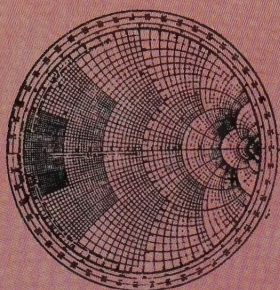


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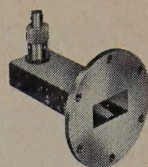
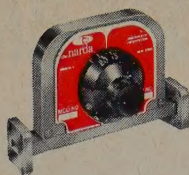
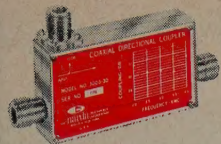
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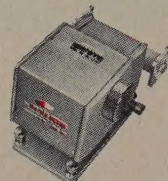
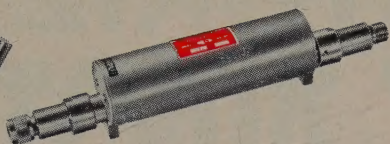
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Communications at Megamile Ranges — Part II

"the microwave journal" is published monthly by Horizon House Inc., William Bazzy, President, Executive Editorial offices at 1330 Beacon Street, Brookline 46, Massachusetts, telephone REgent 4-3220.
"the microwave journal" is issued without charge upon written request to qualified persons working at microwave frequencies in the fields of antennas and propagating electrons and solid state devices, systems, and components manufacturers in the continental United States and Canada, including governmental and university installations. Other subscriptions — continental United States, \$10 per year, single copy, \$1 when available. In Canada, \$15 per year, single copy, \$1.50 when available. Other foreign countries, \$20 per year, single copy, \$2 when available. Copyright © December, 1961, Horizon House — Microwave, Inc. Accepted as controlled circulation publication Boston, Massachusetts.
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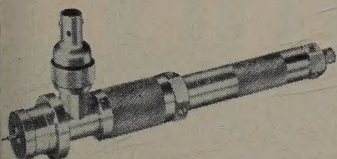




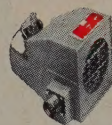
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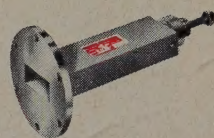
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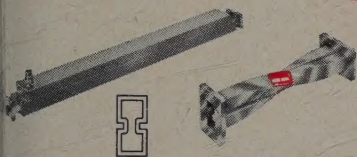
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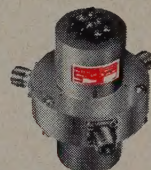
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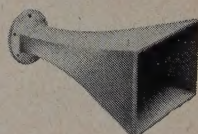
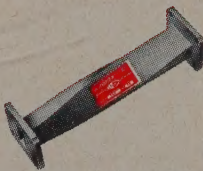
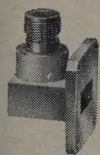
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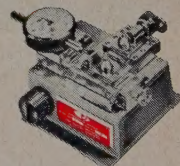
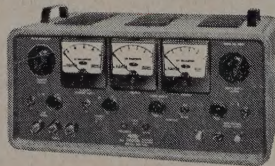
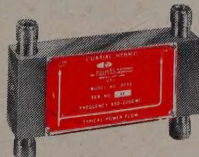
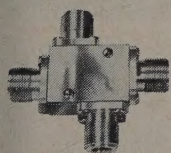
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The expanded line of Sperry isolators available today is proof that—again—Sperry is first in a fast-moving field.

SPECIFICATIONS

Model No.	Frequency (Gc)	Max. Power Peak (Kw)	#Avg. (w)	Insertion Loss (db) Max.	Isolation (db) Min.	Max. VSWR	Transmission Line	Connectors Input	Connectors Output	Dimensions (in.) L	D	Weight (oz.) Approx.
44L11-2	.96 -1.215	10	10	0.8	10.0	1.20	5/8" coax.	N Ma	N Fe	11.11/16	25/32	10
44L7-11	1.025-1.15	5	5	0.5	8.0	1.20	5/8" coax.	N Ma	N Fe	6.39/64	25/32	6 1/4
44L7-13	1.12 -1.25	5	5	1.0	15.0	1.20	5/8" coax.	N Ma	N Fe	7.39/64	25/32	7
44L7	1.25 -1.35	5	5	0.9	15.0	1.20	5/8" coax.	N Ma	N Fe	6.39/64	25/32	6 1/4
44L7-7	1.2 -1.4	5	5	1.0	10.0	1.20	5/8" coax.	N Ma	N Fe	6.39/64	25/32	6 1/2
44L7-15	1.35 -1.45	5	5	0.6	16.0	1.15	5/8" coax.	N Ma	N Fe	6.39/64	25/32	6 1/2
44L7-6	1.435-1.535	5	5	0.6	16.0	1.15	5/8" coax.	N Ma	N Fe	6.39/64	25/32	6 1/4
44L11-3	1.4 -1.6	10	10	0.8	12.0	1.20	7/8" coax.	N Ma	N Fe	11.3/4	1.3/4	11
44L33-25	1.7 -2.3	5	10	1.0	13.0	1.20	5/8" coax.	N Ma	N Fe	9.5/16	25/32	8
44L33-21	1.71 -1.895	5	5	0.7	13.0	1.15	5/8" coax.	N Ma	N Ma	5.1/4	25/32	5
44L33-40	1.75 -1.85	5	5	0.6	20.0	1.15	5/8" coax.	N Fe	N Ma	6.1/16	25/32	6
44L33-41	1.85 -1.95	5	5	0.6	20.0	1.15	5/8" coax.	N Fe	N Ma	6.1/16	25/32	6
44L33-22	1.895-2.01	5	5	0.7	13.0	1.15	5/8" coax.	N Ma	N Fe	5.1/4	25/32	5
44L33-23	2.12 -2.305	5	5	0.7	13.0	1.15	5/8" coax.	N Ma	N Ma	5.1/4	25/32	5
44L33-24	2.230-2.415	5	5	0.7	13.0	1.15	5/8" coax.	N Ma	N Ma	5.1/4	25/32	5
44L33-5	2.0 -2.7	5	5	3.0	40.0	1.20	5/8" coax.	N Ma	N Fe	11.55/64	25/32	12
44S7	2.7 -3.1	5	5	0.9	15.0	1.20	5/8" coax.	N Ma	N Fe	4.11/32	25/32	5
44S7-1	2.7 -3.6	5	5	2.0	20.0	1.20	5/8" coax.	N Ma	N Fe	6.39/64	25/32	6
44C2	4.0 -4.5	5	5	0.9	15.0	1.20	5/8" coax.	N Ma	N Fe	4.7/8	25/32	4
44C2-2	4.4 -5.0	5	5	1.0	15.0	1.15	5/8" coax.	N Ma	N Fe	4.7/8	25/32	4
44C7-4	4.6 -5.2	5	5	0.8	15.0	1.20	5/8" coax.	N Ma	N Fe	3.5/16	25/32	4
44C7-6	4.956	5	5	1.0	30.0	1.15	5/8" coax.	N Ma	N Fe	4.7/8	25/32	4
44C7	5.4 -5.9	5	5	0.9	15.0	1.20	5/8" coax.	N Ma	N Fe	4.11/32	25/32	5
44C7-1	5.745	5	5	1.0	30.0	1.18	5/8" coax.	N Ma	N Fe	4.7/8	53/64	4

Standard stock models

Assume 2:1 Max. Load VSWR

Specifications subject to change without notice.

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MICROVIEWS

OF THE MONTH

79 ► COMMUNICATIONS AT MEGAMILE RANGES R. C. Hansen and R. G. Stephenson — Part 1

Megamile communications call for the fullest use of advanced modern technology. This paper surveys the design of a deep-space communication system. The basic constraints and capabilities of a low-noise ground receiving system are covered in detail, including antenna temperature contributions from galactic noise, tropospheric and ionospheric attenuation, and earth radiation through antenna sidelobes. Low-noise preamplifiers, large high-gain antennas, and narrow-band phase-lock receivers are also considered. Digital biphasic modulation, used in Pioneer V, is compared with more sophisticated bi-orthogonal coding systems. Both types of coding systems are compared with error rate as a parameter with the ideal error-free Shannon limit. The design of Pioneer V and its record of achievement are described. Included are explanations of the coherent transponder within the spacecraft, and of the command transmitter and telemetry reception equipment at the ground stations. The paper is presented in two parts. Part I covers ground station design and system calculations.

86 ► IMPROVING THE GAIN STABILITY OF PARAMETRIC AMPLIFIERS Kenneth M. Johnson

This paper is a discussion of parametric amplifier gain stability. Factors which limit it are considered and ways of maximizing it suggested. The stability limiting factors of VSWR change, pump power change, and temperature change are discussed in detail. Expressions are derived so that the magnitude of the effect of the factors can be computed. It is demonstrated that good stability can be obtained from a broad-band, low-gain amplifier that has a good circulator, proper diode and diode bias, and a stable pump source.

92 ► A COMPACT TUNABLE TUNNEL DIODE S-BAND RECEIVER J. Reindel

Description is given of a tunable low-noise (7 db maximum) S-band receiver consisting of antenna horn, stabilizing network, T.D. amplifier and T.D. down-converter. Design problems are discussed. Performance characteristics are given to illustrate the many advantages of tunnel diode circuits for S-band receivers.

97 ► A WIDE BAND CONICAL SCAN ANTENNA FEED SYSTEM A. D. Bresler, H. Jasik, and A. Kampinsky

For many tracking applications, it is desirable to operate over very wide frequency ranges without the necessity for changing or adjusting the antenna system. A conical scan feed system is described which operates over a frequency range greater than 4 to 1 and which has the inherent capability of operating over still wider ranges. Design principles and typical performance data are given for an experimental system.

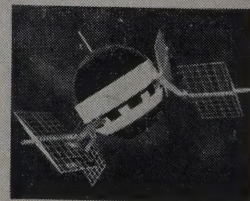
102 ► A VERY BROADBAND MICROWAVE ANTENNA COUPLER K. A. Steele

Relative transmission measurements may be made on microwave systems terminated in antennas by using a reflectionless probe or coupler. For such tests the coupler can be placed in the near-field of the antenna and an antenna range is not required. This technique has applications in laboratory development, maintenance, and production line testing. The construction and performance of a coupler with a useful bandwidth extending from 2 kMc/s to 10 kMc/s is described.

OUR COVER

The cover picture shows the Pioneer V deep space probe designed, built, launched and tracked by Space Technology Labs. for NASA. A Thor-Able booster was used to launch the payload. An article on communications at megamile ranges appears on page 79.

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Also in this issue... INDEX FOR VOLUME IV

the microwave journal

BREAKTHROUGH!

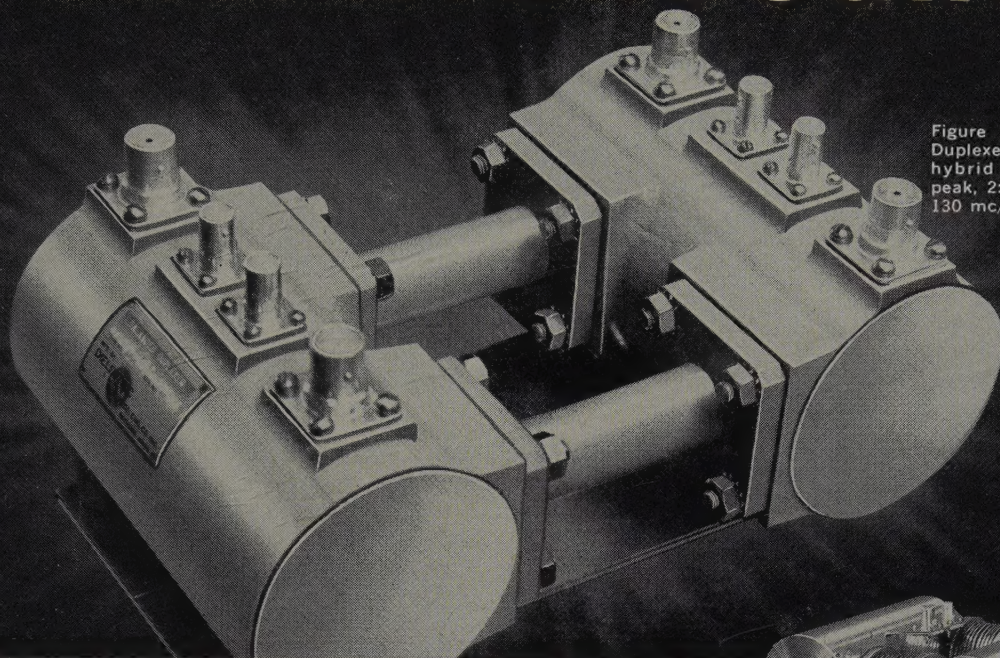


Figure 1. Balanced "ATR" Duplexer employing new hybrid couplers: 10 kw peak, 2:1 band centered on 130 mc/s, weight 5 pounds.

A new, HIGH-POWER, 3 db, crossover

HYBRID COUPLER*

that makes possible duplexers of size and weight heretofore unknown. The crossover feature which allows two outputs on one side provides the maximum flexibility. Unlike many high-power microwave components, this coupler lends itself to design centers as low as 6 mc/s or lower without becoming unreasonably large. Otherwise it has the properties of the classical $\pi/2$ hybrid.

As an example, Figure 1 illustrates application to a balanced "ATR" duplexer centered at 130 mc/s. Over a 2:1 bandwidth, receiver insertion loss is 0.3 db minimal and transmitter insertion loss is less than 0.5 db. Isolation is nominally 30 db. Using tubes especially developed for these duplexers by Tucor, Inc., recovery time is 100 microseconds. This particular unit was furnished for a 10 kw peak, 200 watts average power application; but these ratings can be extended considerably.

Note the size with relation to the connectors. The four larger connectors on outside corners are type C for r-f connections; the four inner are BNC for d-c turns, bypassed, through the r-f circuitry for keep-alive voltages.

Figure 2 is a balanced "TR" duplexer with type LC connectors for transmitter and antenna. Hidden are type N connectors for receiver and termination. The BNC's on top are for keep-alive voltages. This particular unit has a center frequency of 130 mc/s, and will handle 10 kw peak power, 600 watts average.

Patent pending

Dielectric
for solutions to
communications
problems.



DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

When power components 90° out of phase are fed to ports 2 and 3, the combined output will be from port 1 or 4 depending on sign of the phase difference. A similar situation holds with ports 2 and 3 when power components are fed to ports 1 and 4.

When ports 2 and 3, or 1 and 4, are terminated, a nominal 30 db isolation may be expected between the other two ports over a 2:1 frequency band. Note that the angular orientation between ports 1 & 4 and 2 & 3 is unimportant. This fact greatly eases the packaging problem.

For high power capability in a small, light-weight package, specify *Dielectric*. Further information may be obtained from our Proposal Engineering Department.

DIELECTRIC'S areas of capability include coaxial, waveguide and open wire techniques . . .
TRANSMISSION LINES & COMPONENTS • NETWORKS
SWITCHES • ANTENNAS & FEEDS • TEST EQUIPMENT • R & D ENGINEERING

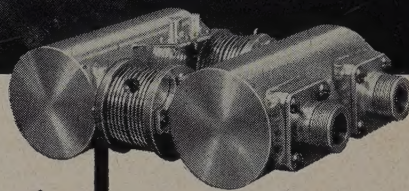


Figure 2. Balanced "TR" Duplexer: specifications similar to those of Figure 1.

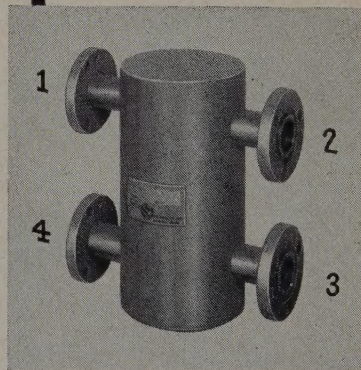


Figure 3. Basic 3 db coupler: orientation between port pairs 1 & 4 and 2 & 3 may be any angle between 90° and 180°. The crossover feature providing two outputs on the same side facilitates application.

THE MICROWAVE MARKET

Over the years the microwave business has had some interesting ups and downs. There was a time not too long ago when a company would quote on an item and have a normal time to develop and produce it in production quantities.

Recently, however, we find ourselves involved in an endless race against time and progress. The quantities required are not quite as large as in past years, but most of the components are becoming more complicated than ever. Today's state of the art becomes a necessity tomorrow, and 30 day delivery in modest production runs is mandatory.

It is a rapidly changing business, not especially suited to the leisure minded business man.

We talk about components, but just as the solid state people have their integrated (?) circuits, so too do the microwave people. The demand is increasing for a number of components combined into a single sub-assembly. And each component is sufficiently complex to be a sub-system in itself.

With the great interest in phased arrays, other problems will begin to appear. New components and sub-assemblies will not only be required immediately, but like components must be electrically identical to a degree not generally required in the past.

The whole atmosphere is one of tremendous activity in many novel and interesting areas.

Missile and space programs have had their influence on the microwave people. In recent years quality control and reliability have begun to exert a growing influence on the design and production techniques of the industry. The prime contractor today demands and often receives equipment that is built to last indefinitely. For a while there will be no one riding the space vehicles or missiles to make repairs or to retune the equipment.

What makes quality control and reliability so important is the vast number of complicated component parts that go to make a single space vehicle. The total cost is astronomical. The failure of a single component can in extreme cases completely destroy a whole program involving millions of dollars and man-years of effort.

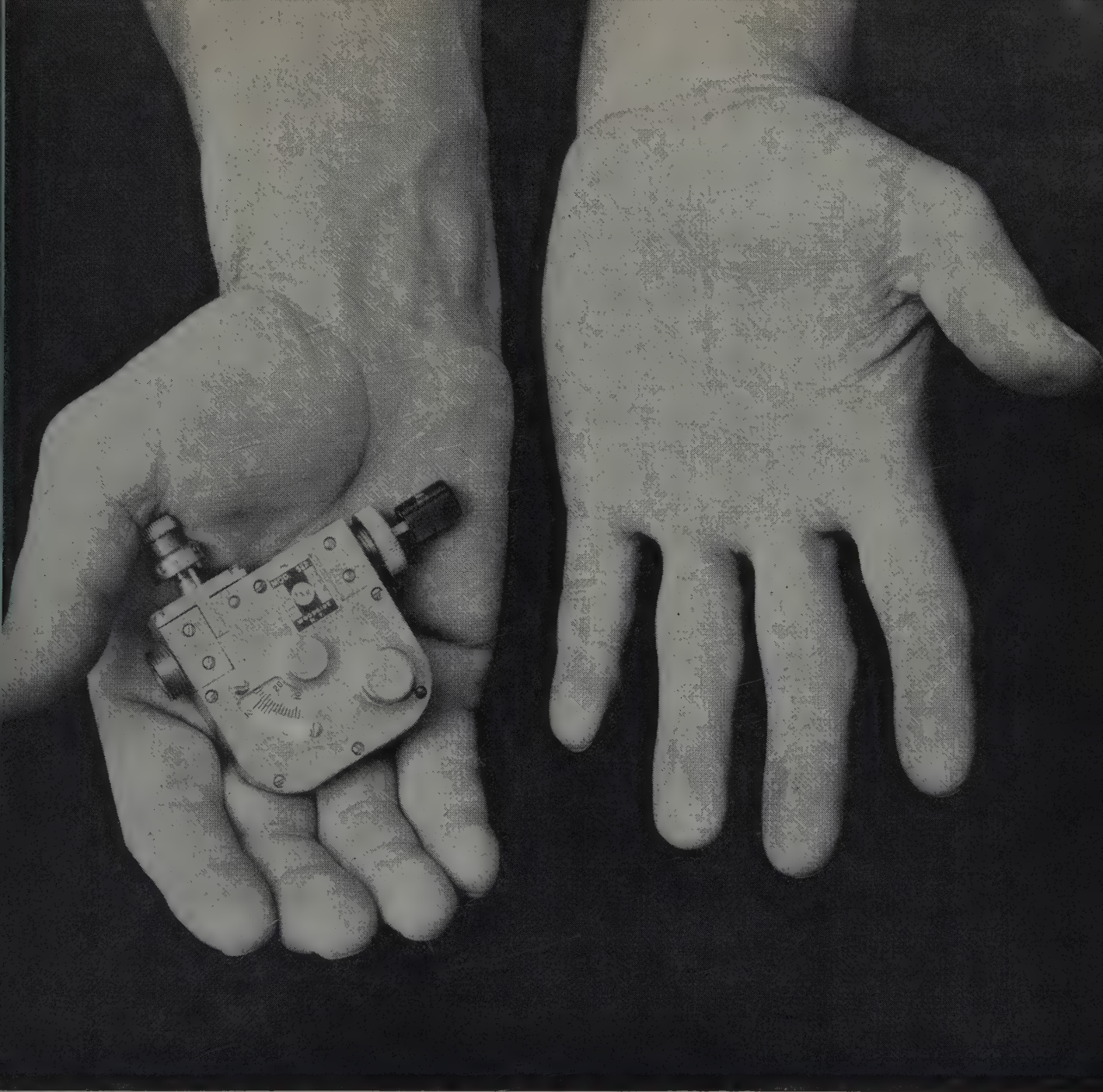
New components in many cases not yet on the drafting board will be required to control phase and amplitude, to multiply, divide, and combine frequencies far more efficiently and in a more precise manner than in the past. New switches, modulators, mixers, phase shifters, and attenuators will be required. Reliability, small size, and great uniformity from piece to piece will be demanded and eventually supplied.

To solve some of these problems, the microwave industry is gradually beginning to turn to solid state techniques. It will have to do so even more in the future.

Some areas of the electronics industry are having their difficult moments. This is not true, however, in microwaves. Here the future looks promising to anyone interested in accepting the challenge.

As the old philosopher once said, "Hard work is its own best reward".

Ted Saad



Wanted: 2 & 3 mm oscillators to power FXR's 90 to 220 Gc components

FXR has on hand *today, in stock*, a complete line of microwave components for tomorrow's 2 & 3 mm systems. And by complete line, we mean frequency meters, precision attenuators, E/H tuners, harmonic generators, phase shifters, bends, twists, slotted sections, transitions — in short, everything needed to set up a test system in the 90 to 220 Gc range.

But what about the 2 & 3 mm oscillators needed to drive these test systems? We've the answer to that. While waiting for these 2 & 3 mm oscillators you, too, can use the FXR harmonic generators for test purposes to double and triple the frequencies of existing oscillators. This

design and production availability of 2 & 3 mm components is a further addition to FXR's comprehensive line of microwave components and test instruments.

Staying a band ahead is a point of pride with FXR engineers. FXR's leadership in the mm bands is typical of equally advanced developments in other areas of microwave engineering, including high power electronics. For example, the FXR engineering group which delivered the world's first 50 megawatt S-band trans-

mitter is now producing even more advanced types. Whether in microwave components, test instruments, sub-systems or high power electronics, FXR is known for its ability to *deliver* the last word in microwave technology today.

May we help you in your next microwave project? Write today for literature covering your particular field of interest. FXR, 25-26 50th Street, Woodside 77, New York. Telephone: Area Code 212, Ravenswood 1-9000.

FXR

THE RF PRODUCTS AND MICROWAVE DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION

Circle Reader Service Card 4

WEGLEIN TO HEAD HUGHES MICROWAVE TUBE DEVELOPMENT

Rolf D. Weglein has been appointed head of product development for Hughes Aircraft Company's microwave tube division, Los Angeles, Cal., W. H. Christoffers, manufacturing manager, has announced. Weglein will direct the development of new products in the manufacturing area and will be responsible for the continual improvement of tubes currently in production.



WEGLEIN

He holds a masters degree in electrical engineering from the California Institute of Technology and is a member of IRE, Tau Beta Pi, Sigma Xi, ARS and the American Physical Society.

— m w j —

BIG GAP CITED BETWEEN SCIENTIFIC KNOW-HOW AND APPLICATION

There is a big gap between scientific know-how and its widespread application in defense and industry, "particularly in the area of electronic circuit theory," according to Dr. Ernst A. Guillemin, Webster professor of electrical engineering at M.I.T. Dr. Guillemin spoke recently at the formal dedication of Burnell & Company's new research laboratory in Cambridge, Mass., named in his honor.

He cited electronic filters, which are found in all electronic circuits, as "an important example." The new Burnell laboratory will concentrate on filter research.

"These vital components of military and industrial control systems and automated processes can be developed and improved more fully to meet the stringent requirements of the space age," Dr. Guillemin said.

Dr. Guillemin, who received the 1961 Medal of Honor of the IRE, is a vice president and director of research for Burnell. He said that research undertaken in the new laboratory can lead to new developments in our national defense warning system, in automated industrial process controls and in improving the safety of air travel.

— m w j —

MANAGER OF ENGINEERING PLANNING APPOINTED BY POLARAD

Polarad Electronics Corp., Long Island City, N. Y., announces the appointment of Stanley Schwalbe to Manager of Engineering Planning. In this position, Mr. Schwalbe will supervise costing, budgeting and scheduling of research, development and production programs for the Defense Products Division.

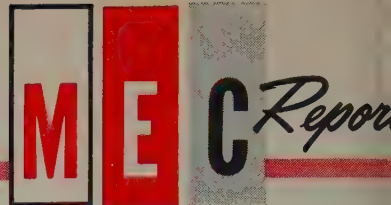


SCHWALBE

development of defense products, scientific instruments and microwave tubes.

— m w j —

(Continued on page 18)



A NEW FAMILY OF Metal Ceramic K_u Band TWT

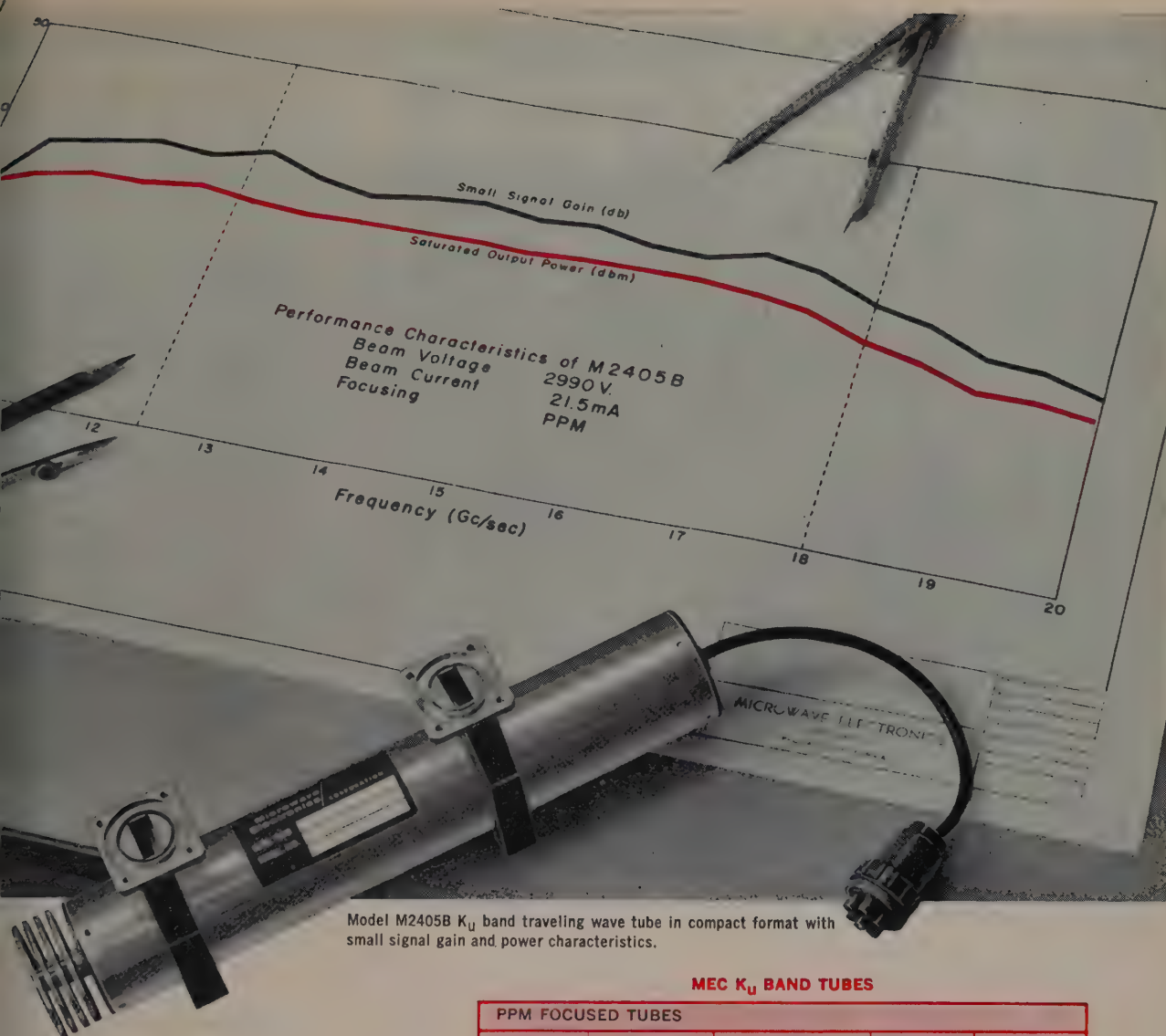
9 Different PPM and Solenoid Focused Tubes Available in Production Quantities

MEC now offers the first complete line of medium power K_u band traveling wave tubes. Rugged and reliable, these new tubes are the result of MEC's proven design and fabrication techniques that are setting the pace for the industry.

A typical member of the MEC K_u band family is the M2405B, a PPM focused medium power tube designed for instrument and industrial applications. Metal ceramic construction permits high temperature processing and exhausts in stable operation, low spurious emission, and high overload capacity. Thermally shielded PPM format eliminates the effect of stray magnetic fields; tubes are mounted close to magnetic materials to prevent arcing between each other.

The M2405B delivers more than 3 watts of power over the major portion of the 10 to 20 Gc range. Greater than 250 milliwatts power can be obtained over the 10 to 20 Gc range with the M2405H, a related tube. Another close relative of the M2405B group functions as a high power generator providing greater than 50 mW output over the 24 to 36 Gc region.

Other tubes in the MEC K_u band family are described in the accompanying table.



MEC K_U BAND TUBES

PPM FOCUSED TUBES				
Tube Type	Frequency Range	Min. Power Output	Min. Small Signal Gain	Noise Figure Max.
M2114B	12.4-18.0	5 mw	25 db	14 db
M2114G	12.4-18.0	5 mw	25 db	20 db
M2208B	12.4-18.0	10 mw	30 db	30 db
M2405B	12.4-18.0	1 watt	30 db	35 db
M2405H	10.0-20.0	1 (12.4-18) watt 0.250 (10-20) watt	30 db 25 db	35 db
SOLENOID FOCUSED TUBES				
M2114A	12.4-18.0	5 mw	25 db	12 db
M2114F	12.4-18.0	5 mw	25 db	17 db
M2208A	12.4-18.0	10 mw	30 db	30 db
M2405F	12.4-18.0	1 watt	30 db	35 db

Environmental Extremes

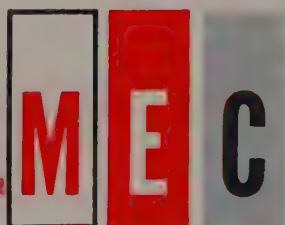
MEC tubes are designed to meet severe environmental extremes. For military applications, tubes can be provided to satisfy the requirements of MIL-E-5400, Class 2. Tubes have been tested at 20 g shock and 15 g vibration from 5 to 2000 cps with no performance degradation.

More Example of MEC Capability

The new K_U band family of traveling wave tubes is another example of MEC's ability to develop tubes for difficult frequency ranges. These tubes are reproducible in production quantities because their metal ceramic format and precision rod supported precision helices ensure dimensional accuracy.

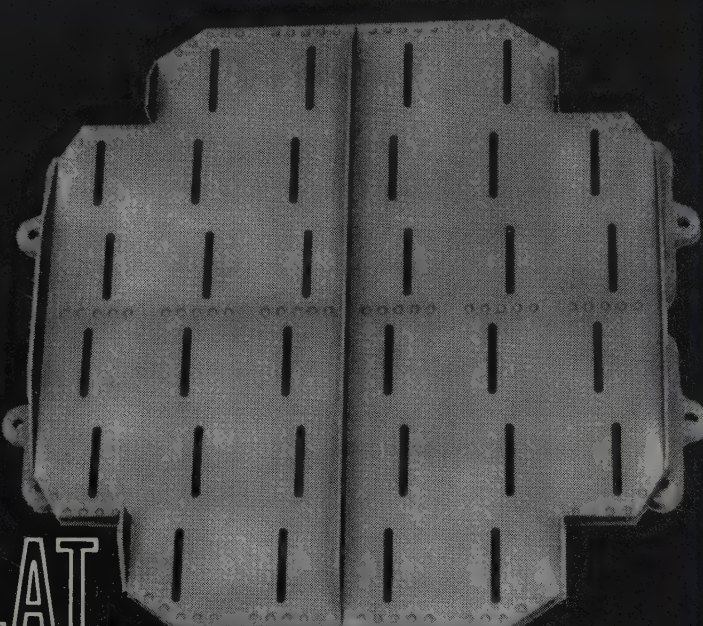
Results obtained in the K_U band assure similar success in the production of broadband traveling wave tubes for higher K band frequencies.

TO KEEP POSTED on current and new developments at MEC, you are invited to ask for a copy of our new catalog. For your copy, call your nearest MEC engineering sales representative or write directly to us.



**MICROWAVE
ELECTRONICS
CORPORATION**

4061 Transport Street
Palo Alto, California
Davenport 1-1770



FLAT PLATES* ARE OLD STUFF!

Way, way back in 1956 (ancient history in the electronic industry) Rantec engineers, led by Lou ■ Kurtz, began working on electronic scanning antennas. Today, Kurtz has brought the "flat plate" slot array antenna "into focus", so to speak, where it is no longer theory alone but an integral component of the guidance packages of missiles and aircraft. Of course, Rantec has an advantage in meeting many of the research problems because Kurtz could rely on the company's long experience in ferrite devices (another "old hat" department). The Rantec "flat plate" slot array does away with mechanical devices and provides for "electronic" conical scanning, beam shaping and changing crossover scan angles. Monopulse operation can also be obtained with integrally packaged hybrids. Gimbal axes can be within several inches of the radiating surface affording larger apertures due to minimum swing space. Because there is no frontal feed interference, there is no blocking of the aperture and very low side lobes result. There is no spillover which means the efficiency is inherently greater than with reflector-type antennas.

Now, let's face it. Can something really be exotic when so many have been produced?



*Rantec's nomenclature
for the slot array.

RANTEC CORPORATION, CALABASAS, CALIF.

CALL LOS ANGELES DI-AMOND 7-5446 • antennas, antenna feed systems, ferrite devices, multiplexers, filters, parametric amplifiers, test instrumentation, and r-f sub-systems



OMEWHERE IN a dim reaches of his an engineer was out into the cruel snowy streets of merce. He was given charge. Sell the de

To our knowledge, this was the first in recorded history an engineer had given the honored (depending upon you look at it) role of salesman. It sh never have happened.

The engineer fresh from the chess board a man of amazing intellect, talent capability. He is also honest (sic) w can cause frightening things to hap The other day, for instance, we turned a trifle white when, at the point when sale was almost signed for, one of our blue engineers said, "Of course, that a age power rating holds true only when What are you going to do. He's too g an engineer to fire.

Selling electronic products and service a hard, hard thing, indeed. The old day the Snake Oil salesman have gone fore About the only thing left, for us here Rantec at any rate, is to engineer a be product or provide a better service. how do you get better than . . . (oh, cu out . . . quit selling).

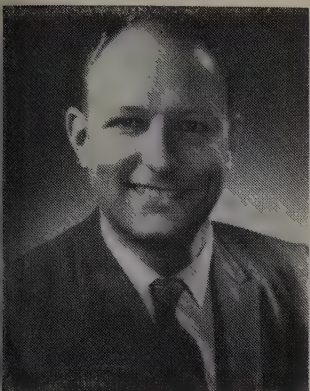
We are reminded at this juncture of an engineer named Terrence Finley (his n is actually Joe Smith, but he prefers remain anonymous) whose quality of cessive ingenuousness "in the field" m him absolutely invaluable. He didn't k this. Therefore, there was no reason to him a raise.

Terrence was a mild man who loved to about isolators and circulators and an tude modulators and switches. He love talk about these things more than he l to talk about girls. Don't damn him this, please. It was just a foible. How Terrence would talk of ferrite devices v such love that nobody could escape his enthusiasm. As a matter of fact, he once 16 circulators to a man who owned a r liquor store. A darling man.

But this was not Terrence's greatest abi In all our years of basking in his electr conversation with customers over lun and dinners and cocktails, we have n seen Terrence pick up a check. How al them apples.

At any rate, if you happen to have bent for purity in engineering (anten ferrites devices, multiplexers, r-f sub tems, test equipment or what have write us a note here at Rantec, Calab California. No sales experience neces Or wanted.

... THERE IS GREAT EXCITEMENT IN EUROPE
ABOUT SPACE SYSTEMS ... "



SPACE COMMUNICATIONS IN PARIS

ROBERT C. HANSEN, ASSOCIATE EDITOR, *the microwave journal*

High over Western U.S.A. at Mach 0.9. — Once again I am fortunate to be able to write about a European scientific conference which I attended. This was a Symposium on Space Communications Research, organized by the space research committee of URSI (International Scientific Radio Union), held at the Ministry of Post, Telephone & Telegraph in Paris, September 18-22. The real subject of the meeting was almost exclusively communications satellites.

At the 1960 General Assembly of URSI, it was decided to emphasize space communications by holding such a meeting; J. R. Pierce was appointed chairman of the committee. Other members were Professor Brown of University College of Wales, Academician Siforov of USSR, and Mr. Voge of the French CNET. A Session was held each morning and afternoon, with 35 papers being presented. One-hundred sixteen people responded to the invitations to attend, so about one in three presented a paper. Arrangements were ably handled by M. duCastel of CNET, and included simultaneous French and English broadcasts which were received by individual receiver/headset combinations. This was my first experience with simultaneous translation, and it offers new possibilities. For example, if the paper was in English and was either dull or familiar, I could tune in the French version and get some decoding practice. There are several U.S. conventions that could stand to offer such a diversion! Attendees were from as far away as New Zealand and Japan, including Switzerland, Italy, Holland, Canada, Australia, Germany, and CCIR. The major delegations were from the U.S., U.K., and France. Unfortunately, no one appeared from any Iron Curtain countries; they probably discovered they could buy the Proceedings later on and save travel money! (Proceedings will be published by Elsevier).

All technical phases of comsats were covered, with one or more papers on the subjects of booster capabilities, attitude control and station keeping, frequency allocations, propagation, interference, voice time delay, environmental testing, FM broadcasting from satellites, and economics. Subjects receiving much emphasis were ground equipment, satellite equipment, modulation, and specific systems (2 sessions). With the exception of the last two sessions, which were given by U.S. speakers, participation was almost magically divided evenly among the U.S., U.K., and France. Only one paper came from elsewhere — West

Germany. The specific systems sessions were of great interest as speakers described the U.S. hardware programs. Jaffe of NASA covered the ECHO I and II program, the RELAY active low altitude satellite, and SYNCOM, the Hughes active spin stabilized equatorial nearly synchronous comsat. Following this, Haviland of GE discussed an intermediate altitude system with station keeping, i.e., with provisions to maintain each satellite in a proper relative position as a function of time. Glaser of BTL then covered ATTCOM (my acronym for the AT&T system), an active random orbit low altitude system. Brown of the U.S. Advent Management Agency briefly covered Advent, an equatorial synchronous repeater with station keeping and attitude control. Next the Needles (West Ford) program of orbiting dipoles was the subject of Morrow from Lincoln Lab.* Finally, Crain of RAND discussed calculations for a satellite broadcasting FM (no commercials, we hope.) Glaser suggested that in a few years we might need an international agency to allocate spots for equatorial synchronous satellites! The Needles program engendered considerable discussion ranging from possible focusing effects of the belt, to how to sweep them out (or down). Regarding sky sweeping, there was some mention in one session about removing high energy particles by sweeping through the radiation belts many times with a suitable satellite. This was followed by an eloquent plea from another camp not to sweep out the radiation belts, as there might be some presently unknown advantage to their presence!

Most of the subjects received attention in one or two papers; the exception was modulation with six papers on this subject, covering the relative merits of various types of amplitude and digital modulation. The two current favorites are FM with feedback (FMFB), and biphase PCM. A straightforward comparison of biphase PCM and FMFB is relatively simple. When the program material is taken into account, the problem includes subjective evaluation of various methods and number of levels used in quantizing and coding the program material. Such studies are underway at several establishments but results are as yet sparse.

(Continued on page 16)

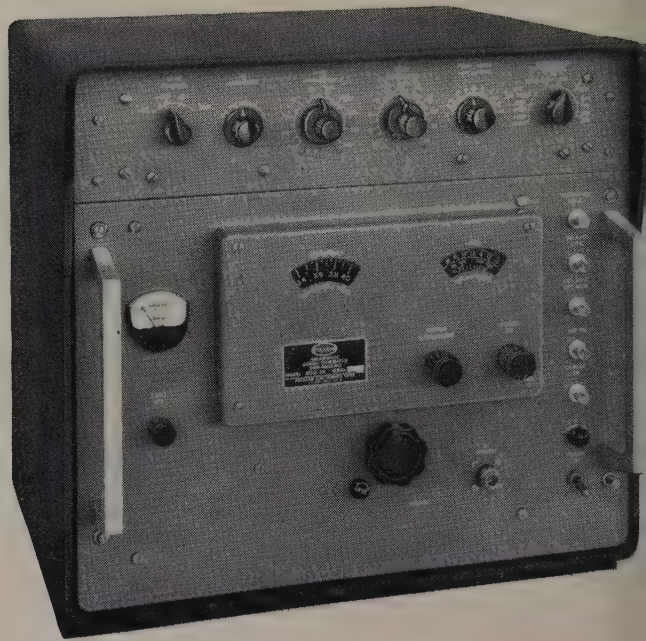
* Shortly after this editorial was written, the needles package was orbited by a MIDAS satellite.

HOW POLARAD'S GENERATORS GUARD



1953

MSG-1 and 2
950 to 4600 mc



1962

.MSG-1R and 2R
950 to 4600 mc

9 years apart...

**exactly
what
are the
differences?**

As you can obviously see, the modern version has had a bit of face-lifting; but that's not all—the main differences lie in improved modulation capabilities; now—the best in the business. For example, internal square wave was 40-4,000 pps, *now* 10-10,000 pps; pulse width was 0.5-10, *now* 0.3-10 μ sec.; pulse repetition rate was 40-4,000 pps; *now* 10-10,000 pps; pulse delay was 2.5-300, *now* 2-2,000 μ sec. But oddly enough, we're proud of both the changes and the lack of changes. The changes have certainly made the MSG-1R and 2R a more sophisticated instrument—a better buy than ever. But the lack of really basic change means the 8-year-old version

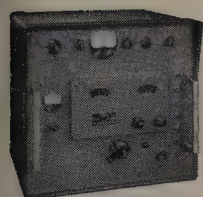
is far from obsolete—it's still a highly competitive unit—it still possesses unusually high stability and accuracy; its direct-reading frequency and power, UNI-DIAL® control and other convenience features save important time and insure accuracy in either

the lab or the field. Moreover, the fundamental retention of the *essential* design, after eight years, means that these instruments are the most *tried and proven* design that ever came down the pike. Concrete proof of Polarad's policy of "features for the future." Write for a copy of Notes on Microwave Measurements.



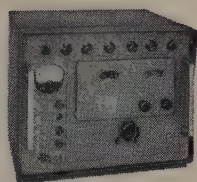
MICROWAVE SIGNAL YOUR INVESTMENT

Which Polarad Generator Solves Your Problem?—500 to 50,000 mc.



Model PMR
500 to 1,000 mc

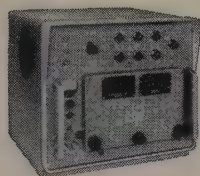
Interchangeable FM or pulse modulators. FM modulator provides low distortion wide-range, sine-wave deviation. Pulse modulator provides pulse, square wave and sawtooth FM. (10-10,000 pps). Calibrated power output: 1 mw



Model MSG 950 to 4,600 mc

	Frequency	Calibrated Power Output	Internal Pulse Modulation				
			Internal Square Wave	Pulse Width in μ sec.	Repetition Rate in pps	Delay in μ sec.	FM deviation in mc minimum
MSG-1	950-2,400 mc	1 mw (0 dbm)	40- 4,000 pps	0.5-10	40- 4,000	2.5-300	± 2.5
MSG-1P*	950-2,400 mc	10 mw (+10 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	± 2.5
MSG-1R	950-2,400 mc	1 mw (0 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	± 2.5
MSG-2A	2,000-4,600 mc	1 mw (0 dbm)	40- 4,000 pps	0.5-10	40- 4,000	2.5-300	± 2.5
MSG-2R	2,000-4,600 mc	1 mw (0 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	± 2.5
MSG-2P*	2,000-4,600 mc	10 mw (+10 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	± 2.5

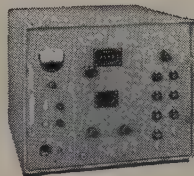
*Attenuator Accuracy: ± 3 db between 0 and +10 dbm.
 ± 2 db below 0 dbm.



Model PMX
4,450 to 8,000 mc
6,950 to 11,000 mc

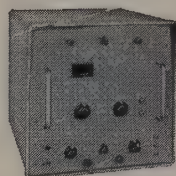
Two interchangeable r-f generator units.

Internal pulse and square wave modulation (10-10,000 pps); 0 to -127 dbm power output.



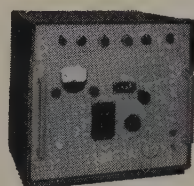
Model MSG-34
4,200 to 11,000 mc
in one instrument

Internal pulse and square wave modulation (10-10,000 pps); 0 to -127 dbm power output; DIGITAL frequency indicator.



Model CSG
SWEEP GENERATOR
1,000 to 16,000 mc
in 5 interchangeable tuning units

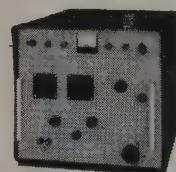
Provides high-power microwave signal adjustable from single frequency to 2:1 frequency range; .001 to 100 cps sweep rate; internal modulation: 1,000 cps and 456 kc square wave; external modulation: square wave, FM and pulse.



Model PMK
10,000 to 21,000 mc
in 2 tuning units

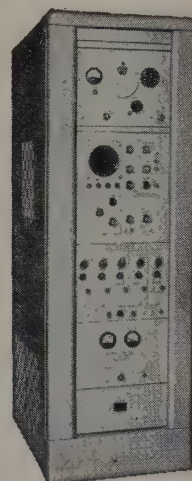
Two interchangeable generator units.

Calibrated power output: +10 dbm (10 mw); internal pulse and square wave modulation (10-10,000 pps); DIGITAL frequency indicator.



EHF SIGNAL GENERATOR
AND SOURCE
12,400 to 50,000 mc

Units in this range provide cw signals, 1,000 cps internal square wave, external modulation provisions, accurate frequency calibration. EHF SIGNAL GENERATOR 18,000 to 39,700 mc, 7 plug-in units. Accurate power calibration. EHF SIGNAL SOURCE 18,000 to 50,000 mc, 9 plug-in units. High power output.



Model B
CODE MODULATOR
MULTI-PULSE GENERATOR
950 to 10,750 mc
in 4 interchangeable tuning units.

Provides 5 independently adjustable pulse channels, each with variable pulse width and delay. Built-in precision oscilloscope.

All Polarad Signal Generators (500 to 21,000 mc) offer:

Continuously variable attenuators calibrated directly in -dbm.

Internal pulse, FM and square wave modulation, external pulse and multi-pulse modulation.

Delayed and undelayed sync outputs.

NI-DIAL® tuning with direct-reading frequency scale accurate to $\pm 1\%$.

High stability non-contacting klystron cavity chokes for noiseless tuning and accurate calibration.

Because each of these fine test instruments has something special about it, a feature or capability that can meet your test requirements exactly, check through this list—then get complete specifications from your local Polarad representative.

POLARAD

ELECTRONICS CORPORATION

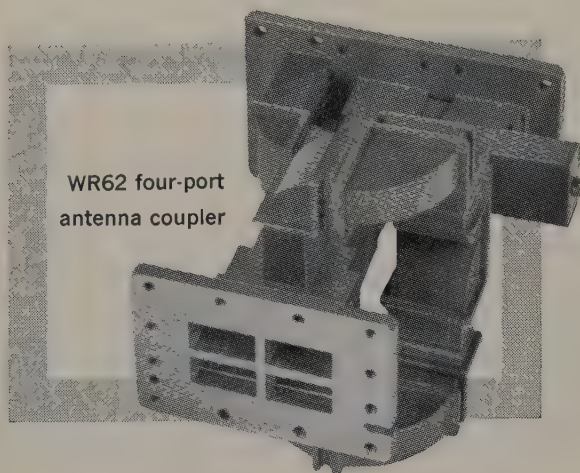
43-20 34TH STREET, LONG ISLAND CITY 1, NEW YORK

FREE LIFETIME
SERVICE

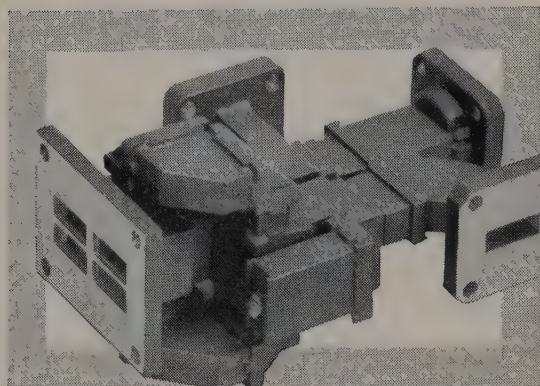
Circle Reader Service Card 7



MONOPULSE ANTENNA COUPLERS



WR62 four-port
antenna coupler



WR42 four-port antenna coupler

MDL monopulse antenna couplers are designed from proven stock components, resulting in quick delivery and lower costs. Exacting quality control assures interchangeability of assemblies and simplified systems design. Each coupler is shipped with certified test results.

MDL monopulse couplers have met these general specifications:

Bandwidth: 10%	
At antenna ports —	
phase relationship:	0° & 180°
phase error:	2° max.
phase deviation	
with frequency:	2° max.
output unbalance:	0.25 db max.
Sum channel VSWR:	1.15 max.
Difference channel VSWR:	1.25 max.

What are *your* monopulse antenna feed requirements?
Send us your specifications today for a prompt quotation.



**Microwave Development
Laboratories, Inc.**

15 Strathmore Road • Natick Industrial Centre • Natick, Massachusetts

telephone: OLYmpic 5-1400 • CEdar 5-6252 • TWX: NTK 295

Circle Reader Service Card 8

HANSEN

(Continued from page 13)

For real time TV (due to time differences, I'm not sure what this would be worth) one needs a brain box to convert among the several line and frame rates, line density, sync signal formats, etc. used in U.S. and European broadcasting. It was during the modulation session that the Symposium achieved some individuality. After one of the papers, a voluble Frenchman got up to make comments which lasted 25 minutes, complete with blackboard drawings and all! This and other things put the schedule off and after 5:30, someone whose time it was to go home pulled the master switch, leaving us with only memories. This type of occurrence is always amusing in that people attending meetings of this sort never have any idea what such prosaic things as main switches are located. However, someone persevered, and the lights and show went on.

A high point not actually on the program was a backstage demonstration of echo suppression by Vincent SRI. A 0.4 sec delay was inserted between two telephones via a tape recorder. The system allowed both ends to talk and be heard; the only effect was the delay in hearing the other person answer. Quality was excellent. It was surprising that without the echo suppressor, the echo was too bothersome; one got used to it quickly.

After all the excitement was over, several impressions remained. First and foremost, there is great excitement in Europe about space systems, particularly comsats, since these would fulfill a practical need. Second, the British and French are now doing things that U.S. scientists did years ago: calculating system performances, orbit coverage, propagation effects, modulation performances, and economic potentialities. Since U.S. scientists are diluted on a vast array of space projects, extra effort may be necessary to stay ahead, although the several hardware programs now in process certainly augur well for our progress. Whether or not any countries not represented in Paris have extensive comsat programs is indeed an intriguing question. The answer may be that one day one will pop out unexpectedly.

With the Blue Streak cancellation and difficulty in other missile programs, the effort and interest seem to be focusing on the satellite and ground station problems. Both areas in which the Europeans can make important contributions without bankrupting themselves.

Many have written their impressions of Paris. As an engineer can hardly hope to compete, especially in a few lines. I will mention only a few things which impinged sharply on the memory. Coffee breaks at the PTT offered beautiful, artistic and tasty pastries and goodies, fancier than I've seen in the U.S., the sanitary facilities across the hall were unbelievably archaic, presenting an incredible contrast. Well-dressed people on the Champs Elysees with almost no regard for such niceties as traffic lights, acting in a fashion we might call 'nouveau riche.' Beautiful, wide tree-lined avenues and scurrying little cars. Tiny shops and excellent restaurants. A reception in the Eiffel Tower restaurant, popping champagne and looking over the city while plutocrats' bombs are being furtively prepared. It was an unforgettable experience, and to those who contemplate such a trip, I offer only one item of advice: rest up thoroughly in advance; the rich food, late hours, and long walks around tourist attractions will be hard on you.

the microwave journal

124 completely hermetically sealed Microwave Mixer and Video Diodes

ARE DIRECTLY SUBSTITUTABLE
FOR CONVENTIONAL DIODES
TO ASSURE UNPRECEDENTED
SYSTEMS RELIABILITY.



Microwave Associates has answered your need for truly hermetically-sealed diodes. For the first time, both fixed-base and reversible polarity types have CERAMIC-TO-METAL SOLDER SEALS plus SOLDER D SEALS.

Whatever the requirement—from 1 Mc to 18 Mc, a new diode is available to replace the present diode — extra high burnout types for high signal level circuits and behind radar detectors—new low-noise types for doppler receivers. The MA-458F, for example, replacing the 1N23E, has a calculated overall noise figure of 7.6 db — the lowest noise figure available for high reliability applications.

These diodes (and coaxial case and subminiature glass packaged diodes) assure military and commercial applications the reliability essential for uninterrupted service for exceptional time spans. They perform to 150°C and meet the applicable environmental requirements of MIL-S-19500.

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Export Sales: Microwave International Corp.
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September, 1961

Circle Reader Service Card 9

SILICON MIXER DIODES

1 Mc — 4,000 Mc

CARTRIDGE CASE

Improved Types

For low noise superheterodyne mixer performance

- Replace 1N21 series

Fixed Base Types		Matched Pair		Reversible Polarity Types	Calc. Overall Rec'd Noise Figure M. 1.5db (db)	Burnout Rating (ergs)
Forward Polarity	Reversed Polarity	Forward Pair	Forward & Reversed			
MA-449B	MA-449BR	MA-449BM	MA-449BMR	MA-459B	10.3	5.0
MA-449C	MA-449CR	MA-449CM	MA-449CMR	MA-459C	8.3	5.0
MA-449D	MA-449DR	MA-449DM	MA-449DMR	MA-459D	7.3	5.0
MA-449E	MA-449ER	MA-449EM	MA-449EMR	1N21WE	7.0	5.0
MA-449F	MA-449FR	MA-449FM	MA-449FMR	MA-459F	6.0	5.0

Higher Burnout Types

For use in pulse radars or other receivers exposed to high RF radiation fields.

- Interchangeable with 1N21 series

MA-4127	MA-4127R	MA-4127M	MA-4127MR	MA-4132	8.3	10
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Lower Noise Types

For best signal-to-noise performance in low frequency IF doppler systems.

MA-4126	MA-4126R	MA-4126M	MA-4126MR	MA-4131	—	2.0
MA-4126A	MA-4126AR	MA-4126AM	MA-4126AMR	MA-4131A	—	2.0

4,000 Mc — 10,000 Mc

Improved Types

For low noise superheterodyne mixer performance.

- Replace 1N23 series

MA-451B	MA-451BR	MA-451BM	MA-451BMR	MA-458B	11.4	2.0
MA-451C	MA-451CR	MA-451CM	MA-451CMR	MA-458C	9.8	2.0
MA-451D	MA-451DR	MA-451DM	MA-451DMR	MA-458D	8.2	2.0
MA-451E	MA-451ER	MA-451EM	MA-451EMR	1N23WE	7.6	2.0
MA-451F	MA-451FR	MA-451FM	MA-451FMR	MA-458F	7.0	2.0

Higher Burnout Types

For use in pulse radars or other receivers exposed to high RF radiation fields.

- Interchangeable with 1N23 series

MA-4133	MA-4133R	MA-4133M	MA-4133MR	MA-4134	9.8	5.0
---------	----------	----------	-----------	---------	-----	-----

Lower Noise Types

For best signal-to-noise performance in low frequency IF doppler systems.

MA-4125	MA-4125R	MA-4125M	MA-4125MR	MA-4130	—	2.0
MA-4125A	MA-4125AR	MA-4125AM	MA-4125AMR	MA-4130A	—	2.0

10,000 Mc — 18,000 Mc

COAXIAL CASE

Improved Types

For low noise superheterodyne mixer performance.

- Replace 1N78 series

MA-443	MA-443R	MA-443M	MA-443MR	—	—	0.6
MA-443A	MA-443AR	MA-443AM	MA-443AMR	—	9.8	0.6
MA-443B	MA-443BR	MA-443BM	MA-443BMR	—	8.8	0.6
MA-445	MA-445R	MA-445M	MA-445MR	—	—	1.0
MA-445A	MA-445AR	MA-445AM	MA-445AMR	—	9.8	1.0
MA-445B	MA-445BR	MA-445BM	MA-445BMR	—	8.8	1.0

Lower Noise Types

For best signal-to-noise performance in low frequency IF doppler systems.

MA-4124	MA-4124R	MA-4124M	MA-4124MR	—	—	0.6
MA-4124A	MA-4124AR	MA-4124AM	MA-4124AMR	—	—	0.6

SILICON VIDEO DIODES

1 Mc — 10,000 Mc

Improved Types

For high tangential signal-to-noise sensitivity in simplified beacon receivers, test equipment and other uses.

- Replace MA-408 series

Fixed Base Types		Reversible Polarity Types	Burnout Rating (ergs)
Forward Polarity	Reversed Polarity		
MA-452	MA-452R	MA-461	1.0
MA-452A	MA-452AR	MA-461A	1.0
MA-452B	MA-452BR	MA-461B	1.0

Higher-Burnout Wide Dynamic Range Types

For use in video receivers exposed to high RF radiation fields.

- Interchangeable with MA-408 series

MA-4128	MA-4128R	MA-4129	5.0
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What Fred Kruse knows about BWOs

If you were to talk shop with Fred Kruse, the "Fred" of Alfred Electronics, the conversation would inevitably get around to BWOs. Fred feels almost paternal about backward-wave oscillators, because he knows them intimately, has been influential in guiding their development, and has worked hand-in-hand with the people who make them. As a result, what Fred knows about BWOs has helped him build a million-dollar manufacturing business.

The primary component in one of Fred's chief product lines — sweep signal generators — is a backward wave oscillator. And since the day he built his first commercial sweeper, Fred has continued to test diligently all makes of BWOs. The results of his hypercritical BWO evaluation are readily apparent in the quality of his product, and in its enviable reputation throughout the electronic industry.

If you buy an Alfred sweep oscillator, chances are ten out of ten its BWO will bear the label of Stewart Engineering Company. For, as Fred Kruse will tell you, "when better BWOs are built, Ray Stewart will build them." Fred knows from experience. And you won't catch Fred using anything but the best.

May we send you our latest BWO catalog?

STEWART

STEWART ENGINEERING COMPANY
Santa Cruz 2, California



Industry News

(Continued from page 10)

P. I. B. SYMPOSIUM DUE ON MATHEMATICAL THEORY OF AUTOMATA

The twelfth annual international Polytechnic Symposium to be held in New York City on April 24-26, 1962, will be devoted to "The Mathematical Theory of Automata". The symposium will emphasize the application of mathematical techniques to information-handling systems.

Specific proposed topics to be included are as follows: Computability, classes of Turing machines and automata, unsolvable problems, problem complexity, symbolic logic, methods for programming logical problems, theorem proving, algorithms for quantification theory, procedures for search and learning, search discontinuous and discrete systems, random versus systematic methods, convergence and random walk, Pandemonium and Perceptrons; abstract algebra, linear graphs; applications of lattice theory, semigroups, rings, etc., to coding languages, and sequential transducers; application of linear graphs to routing problems, state diagrams, etc.; synthesis procedures, design with "neurons" or other specific types of element, reliability.

The objectives of the 1962 Symposium are twofold: 1) to encourage the development and exposition of basic theories and mathematical tools which will be of use to the engineer in analyzing, designing, and using information-handling systems; and 2) to provide a forum for the exchange of ideas among applied mathematicians, computer engineers, those interested in information theory, etc., in the hope of stimulating further development of those branches of mathematics which might be used in a theory of digital devices. The program will contain both invited and contributed papers as well as a round-table discussion of future trends. The proceedings will be published in book form as Volume XII of the Polytechnic Symposia Series.

This year, the symposium is organized by the Departments of Electrical Engineering and Electrophysics in cooperation with the IRE professional groups on Electronic Computers and Information Theory and the Science and Electronics Division of the AIEE. It is co-sponsored by the Air Force Office of Scientific Research, the Office of Naval Research, the U. S. Army Signal Corps. The United Engineering Center, facing the Plaza, will be the site for this meeting. Further information may be obtained from Professors A. E. Laemmel and E. J. Smith, Co-Chairmen of the Symposium Committee.

The closing date for submission of contributed papers or 200-word abstracts is January 5, 1962. Correspondence should be addressed to:

Symposium Committee
Polytechnic Institute of Brooklyn
55 Johnson Street
Brooklyn 1, N. Y.

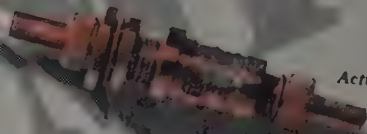
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(Continued on page 20)

the microwave journal

TO: RF Circuit Designers
FROM: **DEUTSCH**

We are so sure you will find the new Deutsch DC subminiature RF connector the most advanced design available today that we will provide you with a production sample absolutely free! Take it apart. Test it for VSWR. Evaluate it in any manner you feel is necessary to demonstrate the performance characteristics we claim. Push-pull coupling with positive lock... crimp-type terminations... captivated contacts... complete environmental seal... all these features give coaxial performance beyond existing specifications.

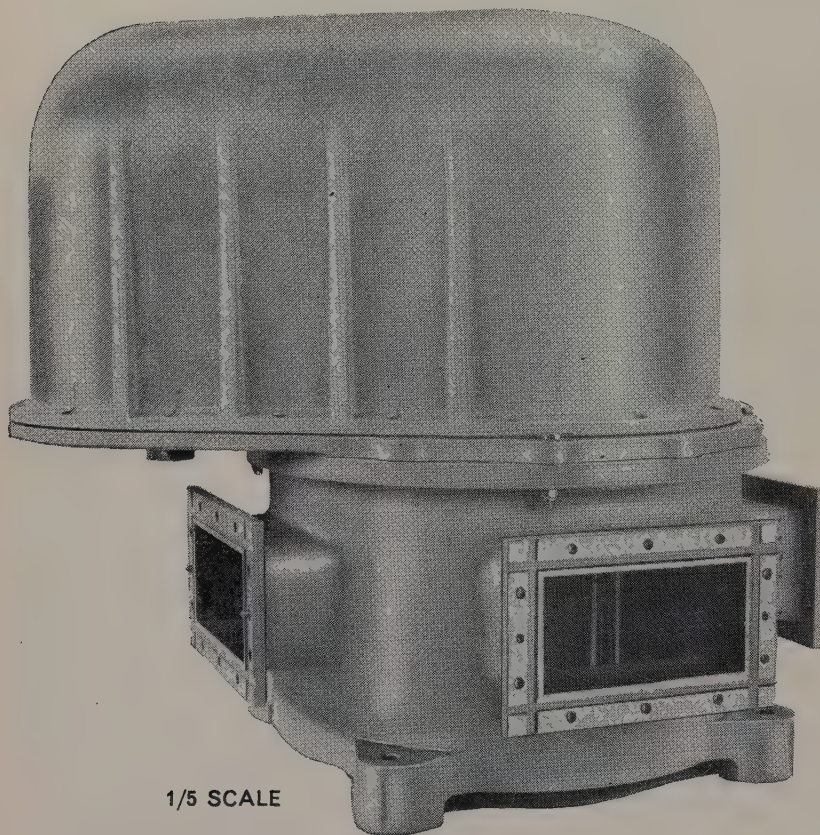


Actual Size

Send for your sample now. Write to Don Underwood at our Banning address on your company letterhead, and we'll get a brand new DC off to you double-quick! Or if you need more facts before you take us up on our offer, contact your local Deutschman, or write for Data File **V-12**  The Deutsch Company, Municipal Airport, Banning, California.

ADVANCED SPECIFICATION MINIATURE ELECTRICAL CONNECTORS

SPLIT



1/5 SCALE

PERSONALITY

IT'S BIG! Our new high power L-Band Switch has a waveguide cross section of $3\frac{1}{4}$ " by $6\frac{1}{2}$ ". It provides quite high electrical isolation between the two RF channels. Minimum guaranteed isolation is 80db. Air pressure can be maintained in one RF channel while the other channel is unpressurized. It maintains pressurization during the switching cycle when it automatically shuts off one transmitter and turns on the second transmitter as soon as the VSWR is in the proper limits. In the normal operating position, this new Airtron Switch has a VSWR of less than 1.10. Send today for complete specifications.

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Industry News

(Continued from page 18)

SEIDEL, OLINER JOIN MERRIMAC

Two leading microwave scientists have joined Merrimac Research & Development Inc., precision microwave component manufacturer, Irvington, N. J. Dr. Harold Seidel is the company's new vice president for research and development. Dr. Arnold Oliner has been elected to Merrimac's Board of Directors, and will continue to serve as a consultant on research policy. Both moves were announced by Paul T. Ranova, newly elected president of Merrimac.

Dr. Seidel will manage and direct the R&D activities; Dr. Oliner will aid in the formulation of policy trends and recommendations in research.

Dr. Seidel, 39, comes to his new position from Bell Telephone Laboratories, where he was active in electron-device research. Considered an authority in the Westinghouse World on microwave ferrite devices and parametric amplifiers, he has been credited along with two other BTL scientists with the first successful operation of the solid-state maser. He was awarded the Microwave Prize in 1957 by the Institute of Radio Engineers Professional Group on Microwave Theory and Techniques.

Dr. Oliner will continue in his present capacity as a research professor in the Microwave Institute of the Polytechnic Institute of Brooklyn. The 40-year-old scientist was graduated magna cum laude from Brooklyn College in 1941 (BA with major in physics), took his PhD from Cornell in 1945.

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WEISS WILL DIRECT ENGINEERING PROGRAMS FOR RAYTHEON

Bernard J. Weiss of Natick, Mass., has been named engineering manager of Raytheon Company's microwave and production equipment department, it has been announced by Donald A. Bordlemay, manager of Raytheon's Microwave Production Equipment Department.

Bordlemay said Weiss will direct the engineering programs for the division's Radarange microwave ovens, Weldpower precision welding systems and ultrasoft grinding equipment.

Weiss joined Raytheon in 1951 as a circuit design engineer for the Microwave and Power Tube Division. Since then he has held various positions in research, testing and product development, principally in developing Raytheon's Radarange oven, now used in restaurant and institutional feeding systems to heat complete meals in seconds with microwave energy.

A native of Omaha, Nebraska, Weiss attended Creighton University, graduating from Iowa State College in 1951 with a degree in Electrical Engineering. He has continued graduate work in engineering at the Massachusetts Institute of Technology and in management at Northeastern University while at Raytheon.

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(Continued on page 22)

the microwave journal

MICROWAVE DEVICE NEWS from SYLVANIA

50%
SMALLER!

75%
LIGHTER!



Low Cost, High Performance

PPM- FOCUSED TWT's

for operation from 1 to 12Gc

Now available from Sylvania—a new family of traveling wave tubes designed for high-performance microwave amplifier applications where economy, compactness, light weight are vital design considerations.

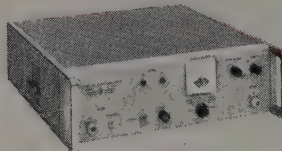
Less than 4 lbs. in weight and 2¼" in maximum diameter, these TWT's present unusual opportunities for compact design of such end-products as microwave test equipment. No electrical performance is sacrificed in attaining these advantages over bulky, 12-16 lb. solenoid types. In addition, they are priced at less than \$1,000 each in quantity.

For further information contact your nearest Sylvania Sales Engineering Office, or write Electronic Tubes Division, Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y.

Frequency Range (Gc)	Sylvania Type	Power Output	Min. Gain (db)
1-2	TW-4267	15mW	35**
1-2	TW-4268	1W	30*
2-4	TW-4261	10mW	35**
2-4	TW-4260	1W	30*
4-8	TW-4281	10mW	35**
4-8	TW-4278	1W	30*
8-12	TW-4282	5mW	35**
8-12	TW-4273	1W	30*

**small signal gain

*at saturation



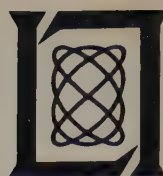
Hewlett-Packard specified Sylvania TWT's in the new versatile 1-Watt amplifiers, Models 489A (1 to 2 Gc) and 491C (2 to 4 Gc).

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS





Lincoln Laboratory is supplementing its staff. The Laboratory is engaged in basic air defense research for the space age. This expanding program is a natural outgrowth of our advanced research and development in the fields of Radio Physics, Radar, Systems Studies, Satellite Surveillance, Computer Technology and Solid State Physics. Senior scientists are invited to join the Laboratory in solving urgent problems of importance to the defense of the United States.

The Laboratory is seeking qualified specialists in:

RADIO PHYSICS and ASTRONOMY

NEW RADAR TECHNIQUES

SOLID STATE PHYSICS and METALLURGY

*A more complete description
of the Laboratory's work will
be sent to you upon request.*

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.



Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 25
LEXINGTON 73, MASSACHUSETTS

Industry News

(Continued from page 20)

NARDA EXPANDS FACILITIES



In a major expansion of its facilities, The Narda Microwave Corp. of Mineola, N. Y., recently moved to its new \$500,000 plant at Plainview, Long Island, N. Y. The new plant will enable Narda to double its present manufacturing capacity.

The new, ultra-modern plant is of a split-level design and unites the best features of a one-level plant with a bi-level plant's space efficiencies. Covering 40,000 square feet on a 3½-acre site, the plant is located at Engineers Hill, Plainview, one of Long Island's fast-growing industrial parks. The new park will provide more than 500,000 square feet of manufacturing facilities eventually.

The one-story section of the building will serve as Narda's manufacturing and assembly area, while the two-story section will accommodate a laboratory and administrative offices.

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TANNER AND JONES JOIN TRG-WEST

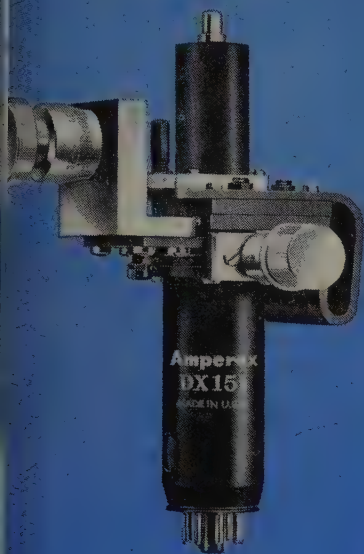
TRG Inc., Antenna and Microwave Dept., Somerville, Mass., announces the formation of TRG-West, a new division to be located in the Stanford area of California. This division will specialize in applied electromagnetic theory, antenna design, microwave components and quantum electronics. Dr. Robert L. Tanner has been appointed Vice President of the division, and Dr. Edward M. T. Jones will be Director of Research.

Dr. Tanner was formerly Head of the Electromagnetics Laboratory at Stanford Research Institute where his interests embraced a number of areas in the field of antennas and related systems problems.

Dr. Jones also came from the Stanford Research Institute where he was Head of the Microwave Group of the Electromagnetics Laboratory. His fields of special interest include both low and high power microwave filters, microwave antennas, stripline components, directional couplers and parametric amplifiers.

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(Continued on page 25)



**For
Millimeter
Microwaves**

Amperex[®] DX-151 mm Reflex Klystron

Manufactured in the United States

Immediately available from stock

TUNING RANGE

to 73kMc minimum

POWER

Guaranteed 100mw midband

LIFE

Guaranteed 250 hours

APPLICATIONS ■ Microwave communications ■ Microwave spectroscopy ■ Radiometry ■ Plasma diagnostics ■ Pumping for parametric amplifier ■ Local Oscillator for Radar ■ Communications testing

Amperex about millimeter-wave tubes for specific applications

December, 1961



In Outer Space

GREAT NEBULA OF ANDROMEDA, COURTESY BETTMAN ARCHIVES



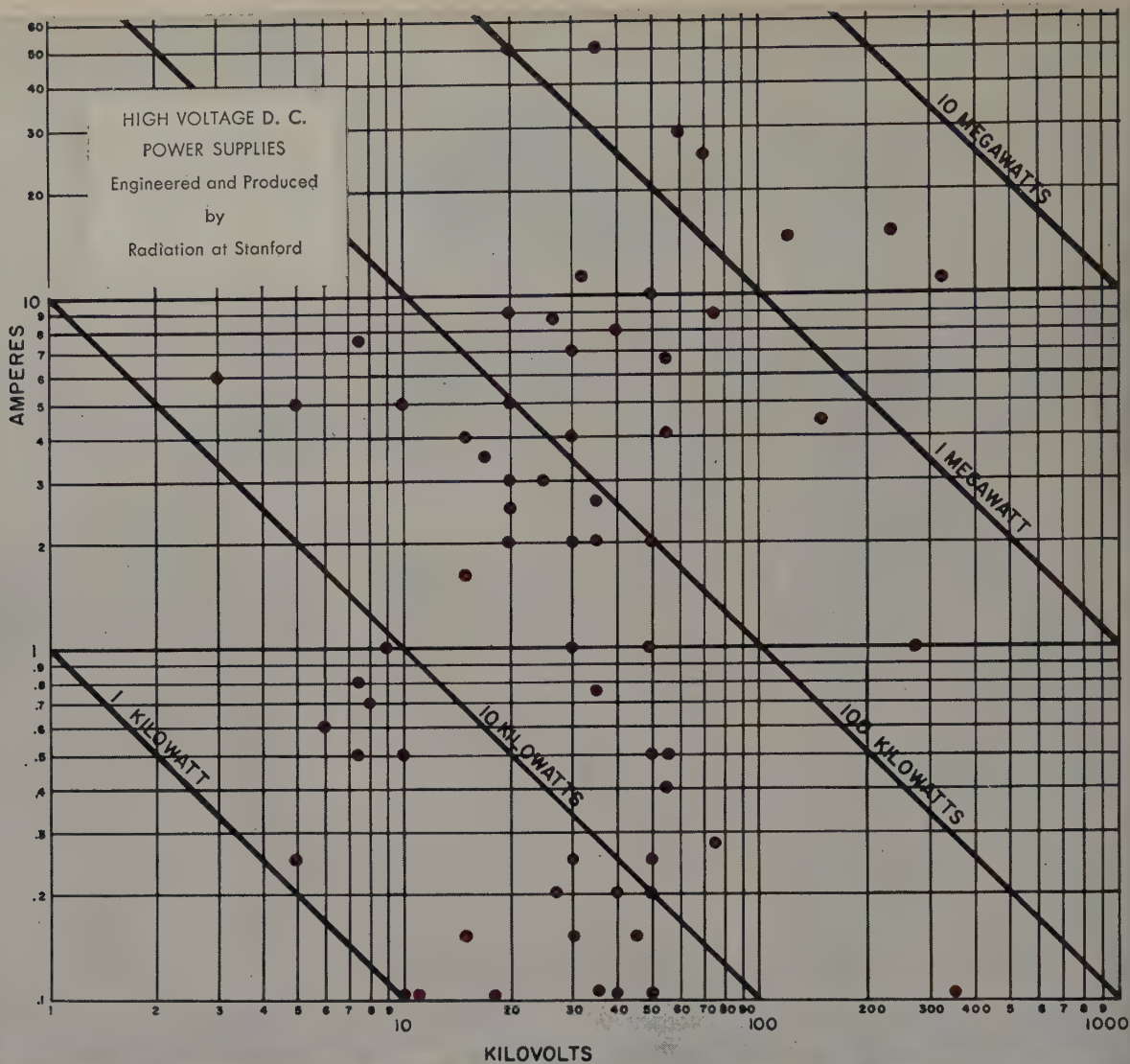
In Inner Space



AMPEREX ELECTRONIC CORPORATION, 230 Duffy Avenue, Hicksville, L. I., N. Y.

In Canada: Philips Electronics Industries, Ltd., Tube, Semiconductor and Components Departments, 116 Vanderhoof Avenue, Toronto 17, Ontario

Circle Reader Service Card 13



CUSTOM SUPPLY SYSTEMS **—ANY POWER YOUR PROJECT REQUIRES**

The chart above shows the range of power supply units engineered and built by Radiation at Stanford. Many of these were for special one-of-a-kind applications. The "shotgun" pattern depicts a breadth of DC power supply experience that is unexcelled in the industry.

Among the custom units we have designed and produced are power supplies for some of the world's most powerful radar and radio telescope transmitters. Megajoule energy

storage systems with ultra-fast crowbar protection are features of these units—and their performance is the measure of our capability in the super-power systems field.

If your project calls for unusual power and an early completion date, bring your problem to us. For specific information, call or write Radiation at Stanford, 3000 Hanover Street, Palo Alto, California.



RADIATION
at Stanford

(Continued from page 22)

MAIMAN ELECTED VICE PRESIDENT AT QUANTATRON

Mr. Richard B. Leng, president of Quantatron, Inc., Santa Monica, Cal., announces the election of Dr. Theodore H. Maiman as a vice president of the corporation.



MAIMAN

Dr. Maiman has for the last six months held the position of Director of the Applied Physics Laboratory in this Santa Monica applied science company. Current activity of the laboratory embraces the entire spectrum of lasers from basic materials research to systems application.

Prior to his association with Quantatron, Dr. Maiman had been with Hughes Aircraft for five of his twelve years professional experience, as senior staff physicist and head of the Quantum Electronics Section. While there, he was responsible for the breakthrough in maser technology which allowed drastic weight reduction and made possible his development of the first liquid nitrogen cooled maser. With this background, he then launched into laser research, which led to his invention of the first ruby laser.

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SAGE APPOINTS JURGEN ELKAN AS MICROWAVE SPECIALIST

Sage Laboratories, Inc., East Natick, Mass., announces the appointment of Mr.



ELKAN

Jurgen Elkan as Microwave Engineering Specialist. In this capacity, Mr. Elkan will be responsible for the development of new lines of microwave components, with initial effort directed to the field of band-pass filters.

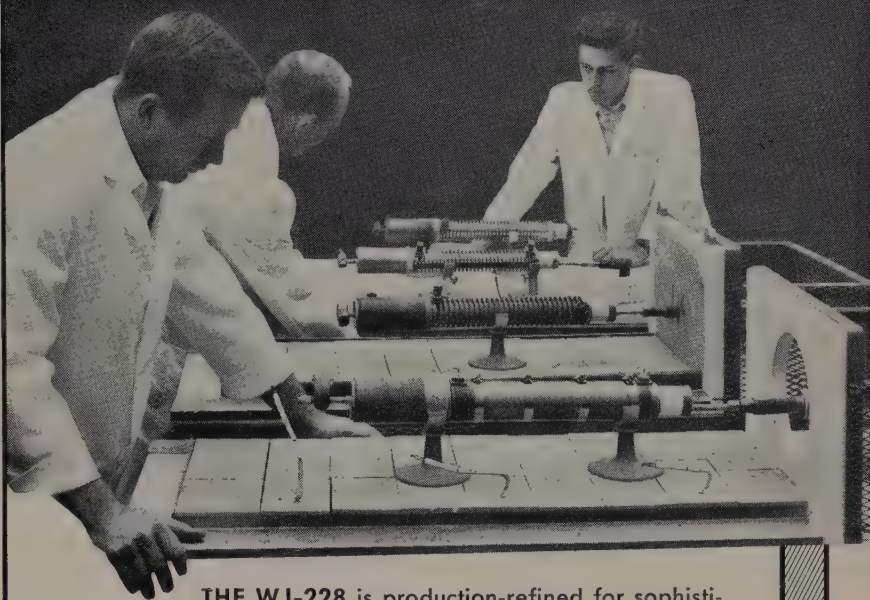
Before joining Sage, Mr. Elkan was affiliated with Hermes Electronics Co., where he directed the communications planning for Weather Observing and Forecasting System 433L and had contributed to the design of HOT LINE, ACE HIGH and other UHF tele-communication systems. From 1951-1955, he was a staff member of M.I.T.'s Lincoln Laboratory and Research Laboratory for Electronics.

Mr. Elkan holds the BSEE and MSEE from M.I.T. He is a member of the IRE and the Society of Sigma Xi and is a registered Professional Engineer in Massachusetts.

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(Continued on page 36)

A HIGH-GAIN TRAVELING-WAVE AMPLIFIER



THE WJ-228 is production-refined for sophisticated C-band radar systems. Considerable investment in engineering skill has gone into this high-gain periodically-focused 14 kw-pulsed TWT amplifier. Unusually small and lightweight and using all metal and ceramic construction, this tube offers high efficiency, high average power and long life. Production quantities are now available on short delivery.

Performance Characteristics

	Typical
Center frequency	5.66 kMc
Bandwidth (3 db)	0.5 kMc
Power output peak	14 kw
Saturation gain	44 db
Duty cycle (max.)	0.024

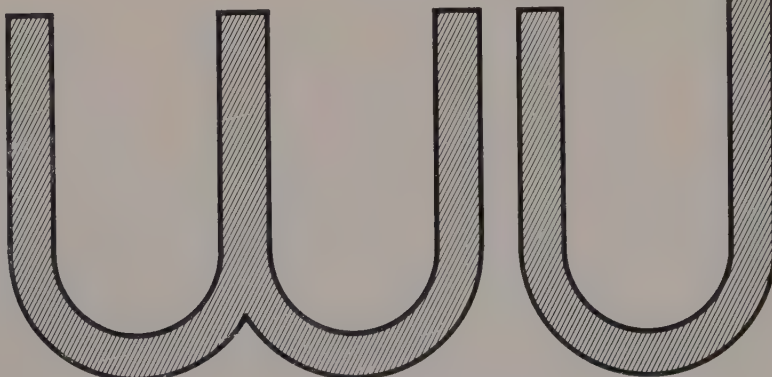
Mechanical

Tube diameter	2.4 inches
Tube length	24 inches
Weight	13 pounds
Coolant	Water

Information in more detail available from representative in your area, or from Applications Engineering

WATKINS-JOHNSON COMPANY

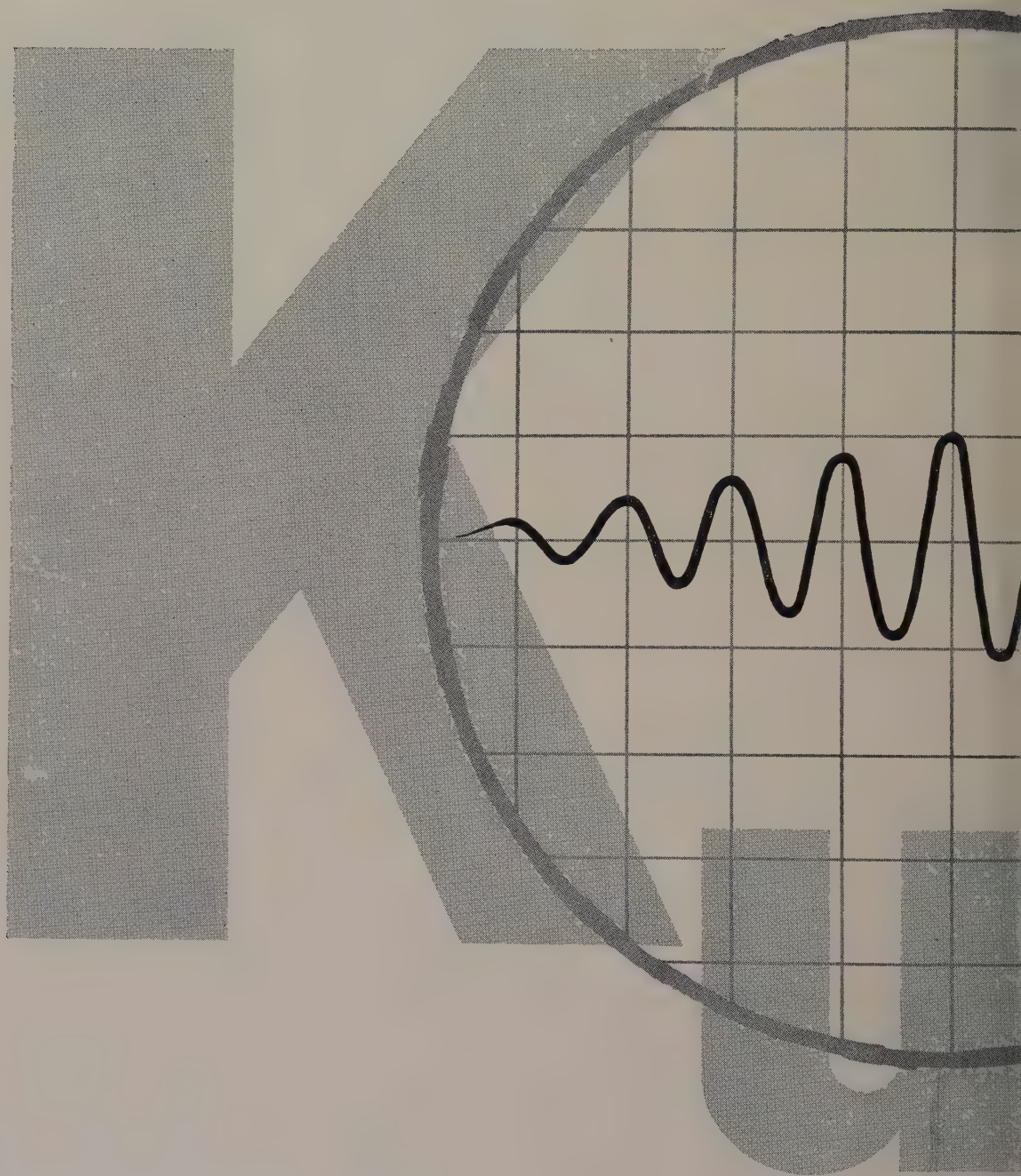
3333 HILLVIEW AVENUE
STANFORD INDUSTRIAL PARK
PALO ALTO, CALIFORNIA





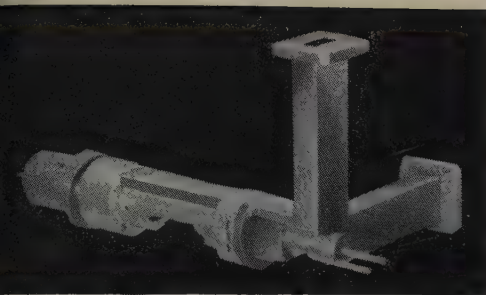
ELECTRONICS

PROGRESS IN MICROWAVE TECHNOLOGY



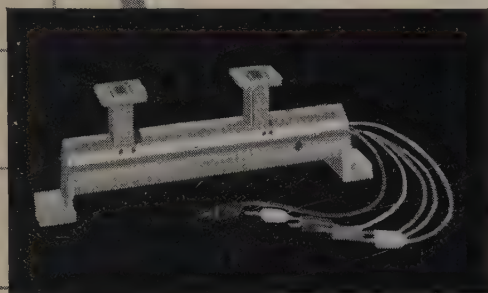
1 Kw 14-18Kmc

General Electric Announces Three K_u Band TWT's With Power Up to 1 Kw



Z-5183 (CW)
(without solenoid)

Saturation Gain.....30 decibels, min
Power Output, CW...10 w, nominal
Length.....9 inches
Weight (including solenoid) 34 pounds



Z-5182 (CW)
(PPM)

Saturation Gain.....30 decibels, min
Power Output, CW...150 mw, min
Length.....11.2 inches
Weight.....3.0 pounds



Z-5184 (Pulsed)
(without solenoid)

Saturation Gain.....25 decibels, min
Power Output, peak...1 kw, nominal
Duty Cycle.....0.01, nominal
Length.....11 inches
Weight (including solenoid) 20 pounds

A significant breakthrough in microwave technology now permits General Electric to offer highest available K_u Band power output.

Developed under an Air Force contract, the three new tubes can be operated singly or in cascade. The highest rated TWT, Z-5184, delivers 1 kw peak. The Z-5183 delivers 10 w CW, and the Z-5182, 150 mw CW.

With their broad bandwidth, high gain, and rugged metal-ceramic construction, General Electric TWT's offer optimum performance in critical applications, such as radar, CW amplification, ECM, microwave relay systems and radiometry. They are also particularly suitable for aircraft and space vehicle systems.

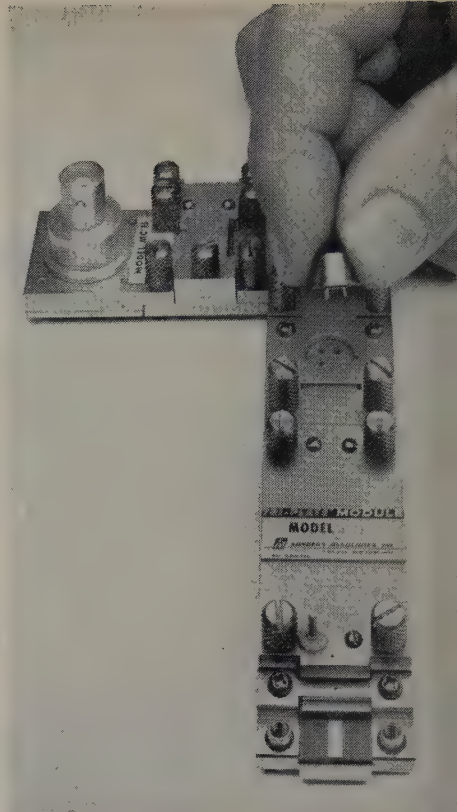
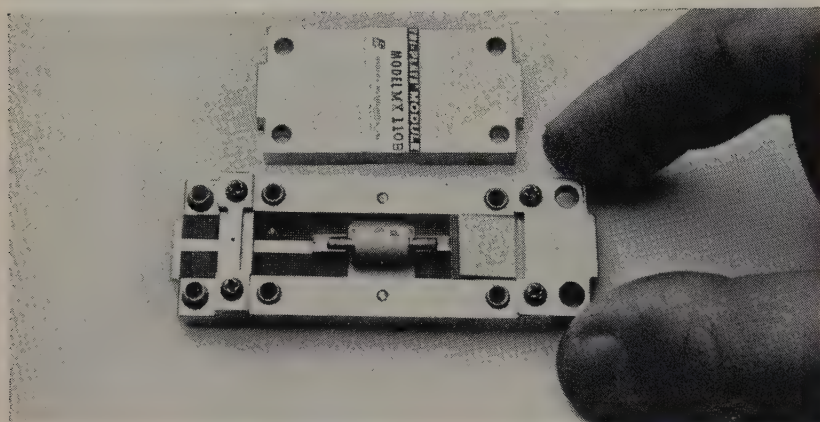
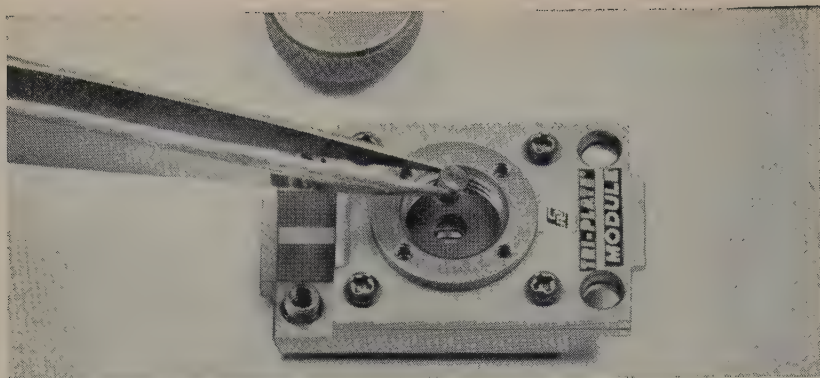
Sample tubes are available for customer evaluation. To obtain more information on these General Electric traveling-wave tubes, contact your nearest Power Tube Sales Office (telephone numbers listed below). Or write to Power Tube Department, G-E Company, Schenectady, N. Y., for bulletin PT-58.

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For your use of pill-type tunnel diodes and varactor diodes when breadboarding advanced semiconductor circuits, cut packaging reactance to minimum with TRI-PLATE Mounts.

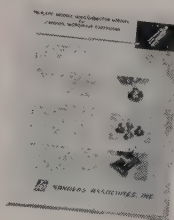
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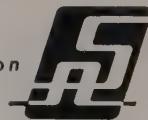
Whatever your goal may be in designing an advanced semiconductor circuit . . . in the microwave or computer engineering field . . . keep in mind that only Sanders offers you over 150 different mounts . . . over 150 different aids in reducing your breadboarding difficulties and delays to a positive, worthwhile minimum. □ With Sanders TRI-PLATE Strip Transmission Line Mounts a practically limitless combination of circuit designs may now be breadboarded *in minutes*. For example, subassemblies using series or shunt mounts . . . 1, 2, 3, 4, 6 or 8 port mounts with choice of RF bypass, ground return and/or bias provision . . .



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the microwave journal

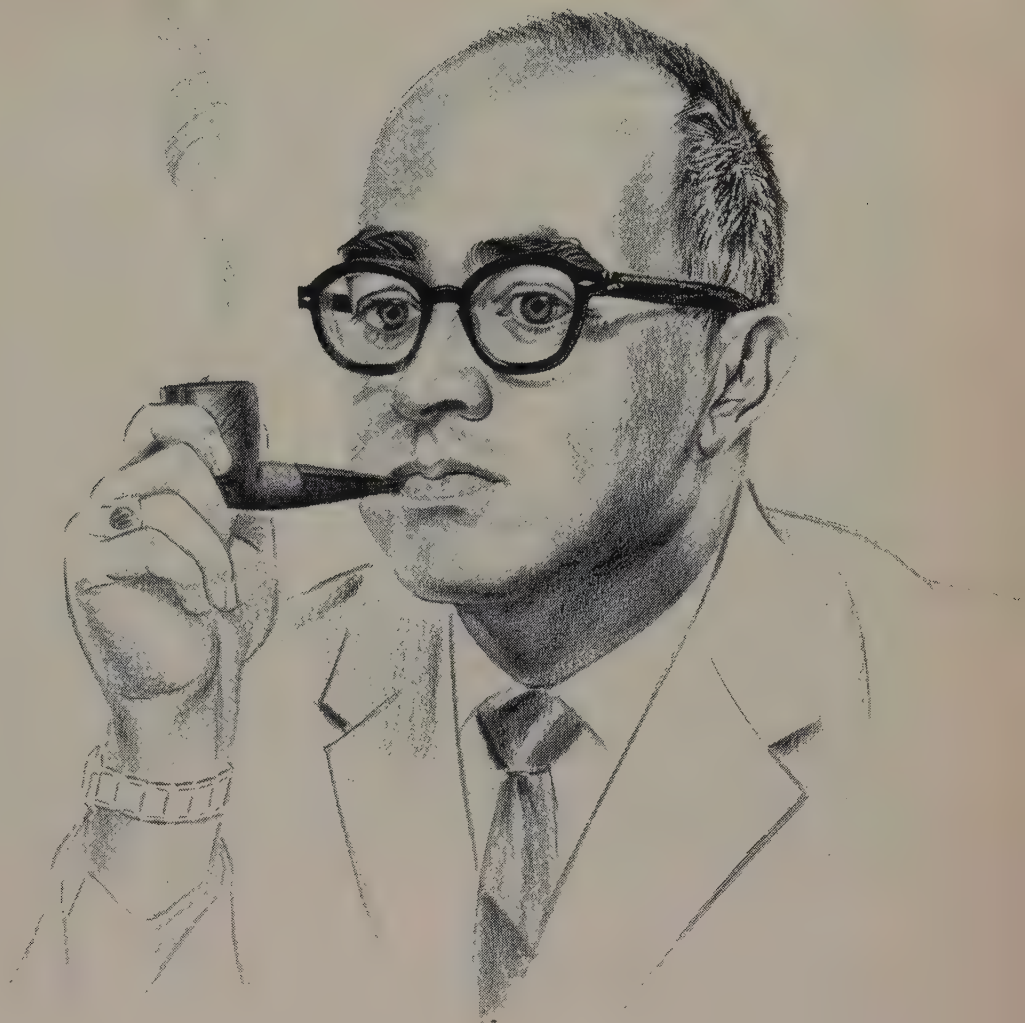
ALBERT J. MORRIS

President

Radiation at Stanford

**Palo Alto,
California**

By **WILLIAM HESTER**



It was the kind of job one dreams about, and it was surprising that the company president recalled it with obvious pleasure. "I got to know everyone in electronics," he said. "I helped pick work for the Navy Department to support, and suggested areas for proposals."

Mr. Albert Morris was describing his job as Scientific Research Coordinator for Electronics at the San Francisco branch of the U.S. Navy Office of Naval Research (ONR). In this capacity he continuously visited all the electronics companies and university laboratories on the West Coast, helped many of them prepare proposals and evaluated the capabilities of laboratories which had submitted them.

"In these several years immediately after the war ONR performed the invaluable service of supporting basic research essentially single handed before the other military agencies and other government agencies were formed to add support to the overall program," he says. "It was a wonderful experience to learn to recognize good work and good people and have money available to provide the required support."

Al's technical inclinations became evident when he was still a child, and he soon knew he wanted to be an engineer. His parents had no technical training but they encouraged him. When Al was 16 and finishing high school in his native New York, his father had a heart attack. Al was sent to an aunt in Los Angeles and

promptly fell in love with California. When his father had recovered, rather than return to New York, Al convinced his parents to move to California.

Al enrolled in the University of California. He spent 2½ years at the Los Angeles campus and 2½ more in Berkeley. He received a B.S. degree in 1941 in both mechanical and electrical engineering.

After a very brief stay in industry, he entered the Navy as an electronics officer in 1942. Ensign Morris attended M.I.T.'s radar school and subsequently was an electronics officer on an aircraft carrier and a member of the Airborne Coordinating Group of NRL. He was discharged as a Lieutenant in 1945. He is presently a Commander in the Naval Reserve.

At this point in his career Al entered ONR, an important milestone. In this job he met the "big names" in electronics and those who would some day be "big names." The top men in the industry today recall him as an earnest worker, eager to learn, and smart enough to know that he didn't know what all the new work was about. He asked questions and was able to learn more about electronics than he could learn in formal courses.

Nevertheless, Al felt that graduate work was necessary. He enrolled at Stanford on a part-time basis while employed at ONR. In 1948, he received his M.S. degree in

(Continued on page 30)

WHEELER Laboratories, Inc.

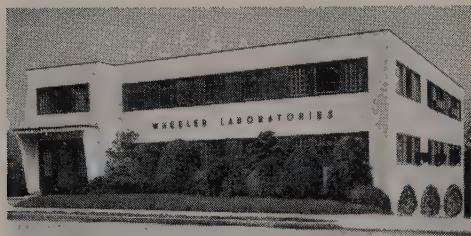
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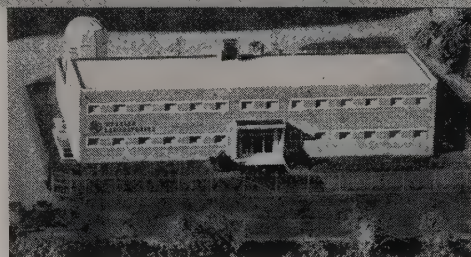
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HAROLD A. WHEELER
and Engineering Staff

MORRIS

(Continued from page 29)

electrical engineering. At this time Nicholas Minor, a visiting professor at Stanford, had a five-ton model destroyer delivered to the University and wanted some work done on ship stabilization. Al Morris decided to work on it and got an appointment as a part-time research associate at Stanford while still retaining his Olin job. Another Stanford student, Joe Chadwick, who was working on servos towards his Ph.D., teamed up with him.

"We christened the model the U.S.S. Minorsky," said, "and worked on it for five years." The work they did was excellent thesis material. Joe Chadwick used the theoretical work for his Ph.D. thesis, and Al Morris used the experimental work to get the degree of engineering in 1950. His thesis was "The Anti-Roll Stabilization of Ships by Means of Activated Tanks." They later studied gyro and fin stabilization and developed a morphological model of all possible stabilization systems only to find that all basic approaches had already been invented.

In 1951, the Navy was interested in awarding a contract for a specific ship-stabilization design problem. At this time Joe Chadwick and Al Morris knew more about the subject than anyone else, and so were asked to take the job. They suggested that the best way to do it would be to set up a company and submit a proposal. The Navy Commander at Bu Ships agreed.

The new entrepreneurs borrowed \$3000 and formed Chadwick-Morris Ship Stabilization Engineering in August, 1951. They had stationery printed and submitted a proposal. To no one's surprise, they were awarded the contract.

For two days, all went well. Then came a request asking Al to appear before the Judge Advocate of the Navy. There they learned that Albert J. Morris was still an employee of ONR (even though on leave of absence).



Mr. Morris poses beside the Morris Defibrillator, a machine for heart shock therapy (circa 1952). This part-time enterprise was small but financially successful.

(Continued on page 32)

RAYTHEON HIGH-POWER FERRITE DEVICES

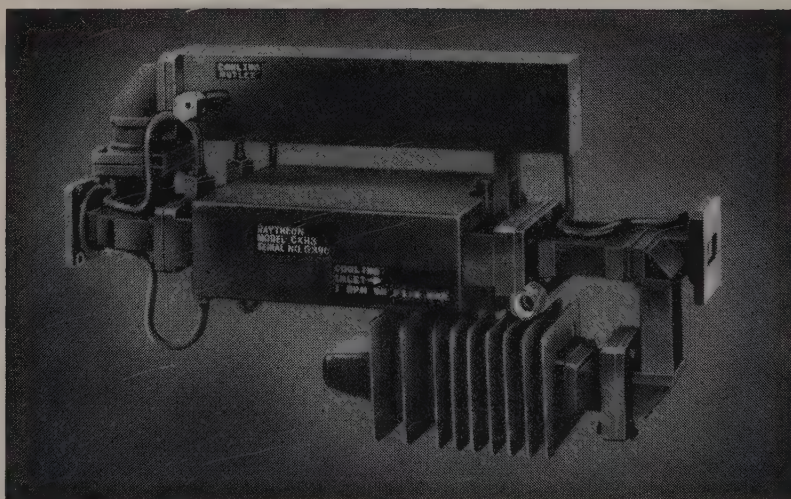
BAND	RAYTHEON MODEL	FUNCTION	POWER LEVEL	
			Average	Peak
UHF	IUH11	Isolator	100 kW	400 kw*
L	CLH4	Circulator	150 kW	2.5 Mw*
	ILH31	Isolator	15 kW	3.5 Mw*
S	CSH9	Circulator	100 kW	
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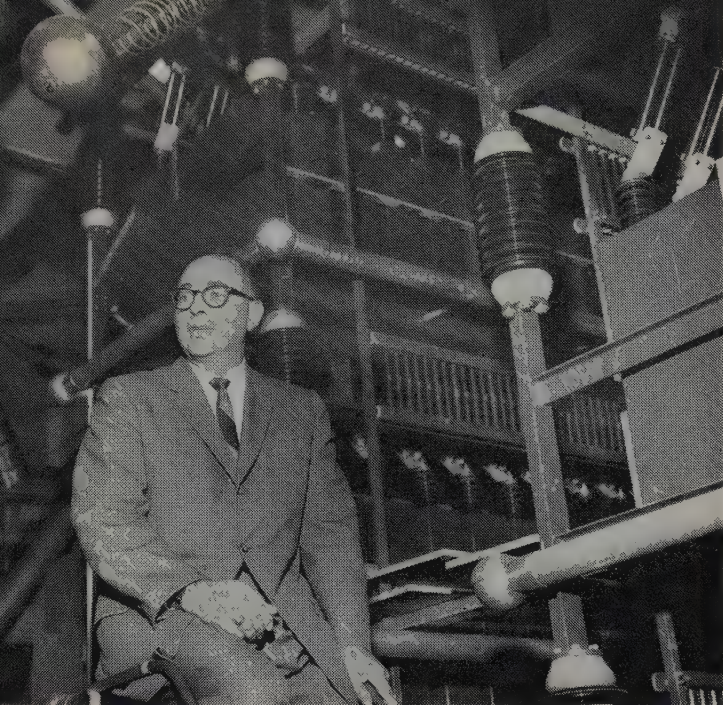
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High Power equipment manufactured by his company forms a backdrop for the president of Radiation at Stanford.

MORRIS

(Continued from page 30)

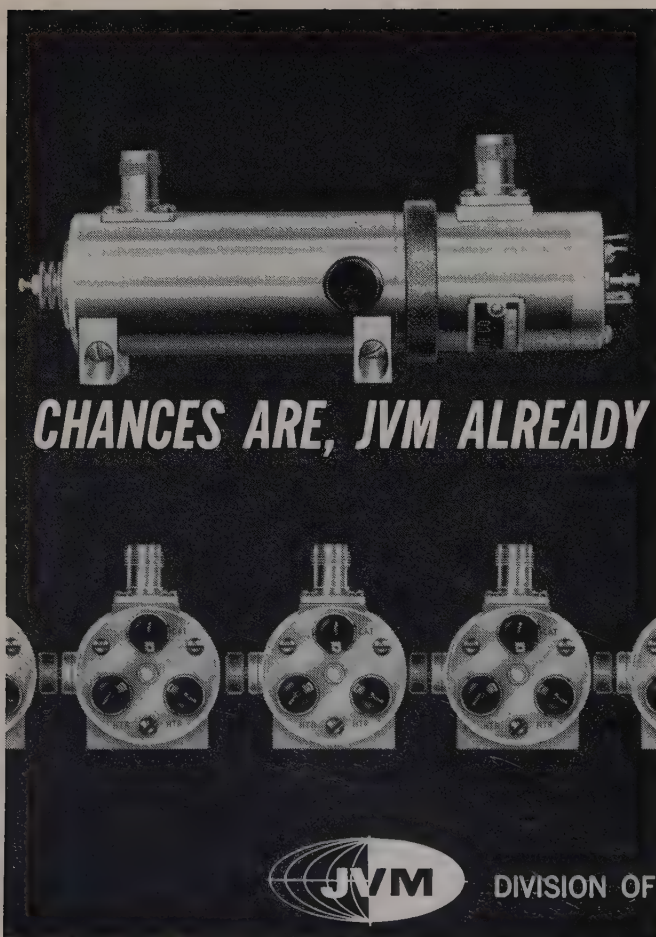
as such could not legally be awarded a contract from any government agency. The Commander at Bu Ships tried to make Al's resignation from ONR retroactive, but to

no avail. The contract was cancelled. ONR did pay Al expenses since he was still in their employ and Stanford paid Joe Chadwick out of funds from a Navy contract. Chadwick-Morris was dissolved after a most unusual record: one proposal written, one contract received, one contract cancelled. Joe Chadwick left Stanford to go to work for Sperry. He gave Sperry a commanding lead in ship stabilization business.

In January, 1952, Al Morris started a new part-time enterprise, the Morris Defibrillator Company, to manufacture machines for heart shock therapy. In his research, he found references to electric shock therapy as far back as 1765. The company was small, but financially successful.

About a year later, Elliott Levinthal was planning to start a new electronics company. He invited Al Morris to join him. After several informal discussions, Al Morris accepted the call. In September, 1953, Levinthal Electronics Products was formed and shortly afterward absorbed the Morris Defibrillator Company. Albert Morris became vice president and chief engineer of the new firm. Both men realized that new developments in high-power microwave tube design were advancing faster than the facilities and supplies for these components. The new company concentrated in the high power field, including transmitters, modulators and power supplies, and kept well abreast of the new tube developments.

(Continued on page 34)



CHANCES ARE, JVM ALREADY HAS A TRIODE CAVITY TO FIT YOUR NEEDS

There are now over 350 proved models of triode cavity in the Mercury "10" series. Cavity designs range from 220 MC to the limits of planar triode frequencies. Functions include oscillating, amplifying and frequency multiplying. Any one of these standardized models can be supplied for R & D, prototype and production use in 30 days or less. Take advantage of these exclusive JVM engineering advances — low cost standardization, production, off-the-shelf availability and design flexibility with uniform performance.

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Andrew radomes provide excellent 2-way year-round protection for Andrew microwave antenna systems. First, they protect feed and reflecting surface against the attenuating effects of snow, ice and debris accumulation. Secondly, for tower mounted antennas they reduce the effects of wind thrust by 35%.

All Andrew radomes are lightweight and easy to install—clip directly to the dish rim of existing antennas. Unheated radomes are suitable for all but exceptional cases. In areas where freezing rain occurs, heated radomes can be provided.

SPECIFICATIONS STANDARD RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc	Thrust at* 30 psf (Flats), lbs.
10	R10	0.4	0.02	1,990
8	R8	0.4	0.02	1,270
6	R6	0.4	0.02	714
4	R4	0.4	0.02	320
2	R2	0.4	0.02	75

*Including antenna

HEATED RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc.	Thrust at* 30 psf. (Flats), lbs.	Power** Reqmts.
10	HR10	0.7	0.02	1,990	3,400 watts
8	HR8	0.7	0.02	1,270	2,400 watts
6	HR6	0.7	0.02	714	1,200 watts
4	HR4	0.7	0.02	320	550 watts
2	HR2	0.7	0.02	75	150 watts

*Including antenna

**Power requirements for HR10 and HR8 are 3 wire single phase 60 cycle 220 volts.

Power requirements for HR6, HR4 and HR2 are single phase 60 cycle 115 v.

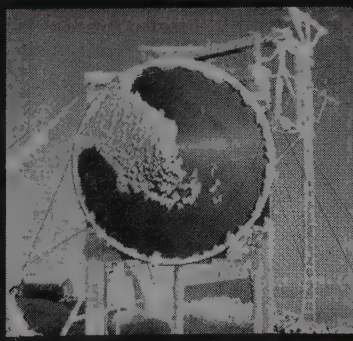
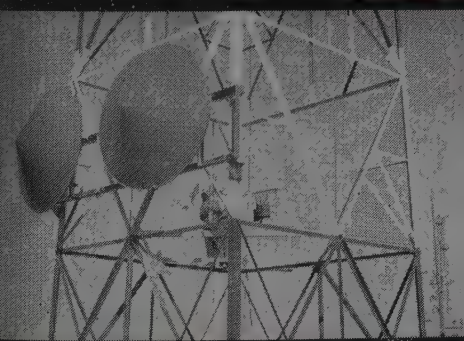
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"We have paid particular attention to antennas during high wind conditions of gusts up to 40-60 m.p.h. It is very obvious that these radomes quite materially reduce the wind loading on the parabolas—due to their shape factor." *Washington State Patrol, Kennewick, Washington*

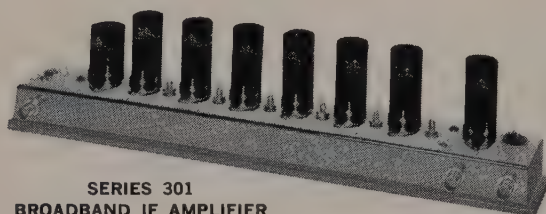
"We have had up to four inches of ice on the radome with practically no reduction of antenna effectiveness." *KLIX-AM-TV, The KLIX Corporation, Twin Falls, Idaho*

"Our field forces report that the radomes produce a signal loss of less than 1 db per antenna. Several radomes were removed and antennas inspected following a heavy snow storm and no snow or ice was found in the antennas." *Natural Gas Pipeline Company of America*

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Project Engineers and designers, in the receiving system field, have checked LEL's line of sub-assemblies and components against every requirement standard and seldom has any equipment received such wide recognition. Needless to state that users of LEL's Broadband IF Amplifiers have also proved to themselves the matchless quality by which these units assure reliability in every advanced high-performance system of which they are a part. This standard makes LEL a **must** source for sub-assemblies and components in the building of narrow or broadband systems.

Series 301 is the newest addition to LEL's line of broadband IF Amplifiers. A miniature amplifier, it is designed to operate with all LEL IF31 preamplifiers as well as LEL's coaxial and waveguide mixer-preamplifiers.



SERIES 301
BROADBAND IF AMPLIFIER

SPECIFICATIONS

Voltage Gain	90db to detector
Center Frequency	30mc or 60mc
Noise Figure (Typical)	1.5db or 2.5db
Bandwidth	10mc at 3db
Dimensions	14½ x 3½ x 2½"

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MORRIS

(Continued from page 32)

Levinthal Electric Products quickly outgrew its quarters in Redwood City, California. In 1956, the company moved to a new building in Stanford Industrial Park. More buildings were added as the company grew and prospered.

In May, 1959, Levinthal Electronic Products merged with and became a subsidiary of Radiation, Incorporated, a space-oriented firm in Florida. Albert Morris was appointed Senior Vice President, Engineering. In December, 1960, the name of the subsidiary was changed to Radiation at Stanford, and Albert Morris moved up to the presidency. Under his direction the company continues its original concept of anticipating new high-power tube developments. He has added new lines to meet future requirements and has discontinued lines which would soon be outmoded. The company continues to grow and prosper.

Because he has an enthusiastic interest in all facets of electronics, Al is continually involved in extra-curricular projects. He and three of his associates at Radiation at Stanford are editing a book on pulse generators for McGraw-Hill. Contributing authors are spread across the country. Al is also a member of the Engineering Advisory Council of the University of California.

Over the years Al has maintained an active interest in the IRE. He belongs to the professional groups on microwaves, medical electronics, and instrumentation. He is founder and past chairman of the San Francisco chapter on medical electronics and was a member of the National Administrative Committee of this professional group. He is a Past Chairman of the San Francisco Section of the IRE and was a director of this section in 1961. He was a director of Wescon in 1958 and 1960, convention director in 1959, and chairman of the Wescon Board in 1961. While chairman of the San Francisco Section, Al was instrumental in starting *The Grid*, now the official publication of the IRE in this area.

Al met his wife, Barbara, while they were both studying at Berkeley, but marriage seemed remote then. In 1943, while Al was teaching at the Navy indoctrination school at the University of Arizona he called Barbara and she joined him in Arizona, where they were married. They have a son, Peter Alan, 16, and two daughters, Ellen, 13, and Lisa Ann, 3. Peter has decided to follow in his father's footsteps and be an engineer. They live in Los Altos Hills, a few miles from Radiation at Stanford.

Al plays as zealously as he works. His interests are many and he possesses a joie de vivre unusual for a man in his position. An active man, he enjoys tennis, golf and water skiing. For more leisurely activity, Al plays poker or bridge and occasionally goes fishing. His wife is a devoted gardener and spends every spare moment in her Japanese garden.

Albert Morris has patents in the modulator field and has made major contributions in three different fields: medical electronics, ship stabilization, and super-power modulators and transmitters. He has come a long way from civil service job to company president. Most men in similar circumstances would be willing to rest on their laurels, but Al's enthusiasm and energy seem limitless as he looks for new fields to investigate, new interests to cultivate.

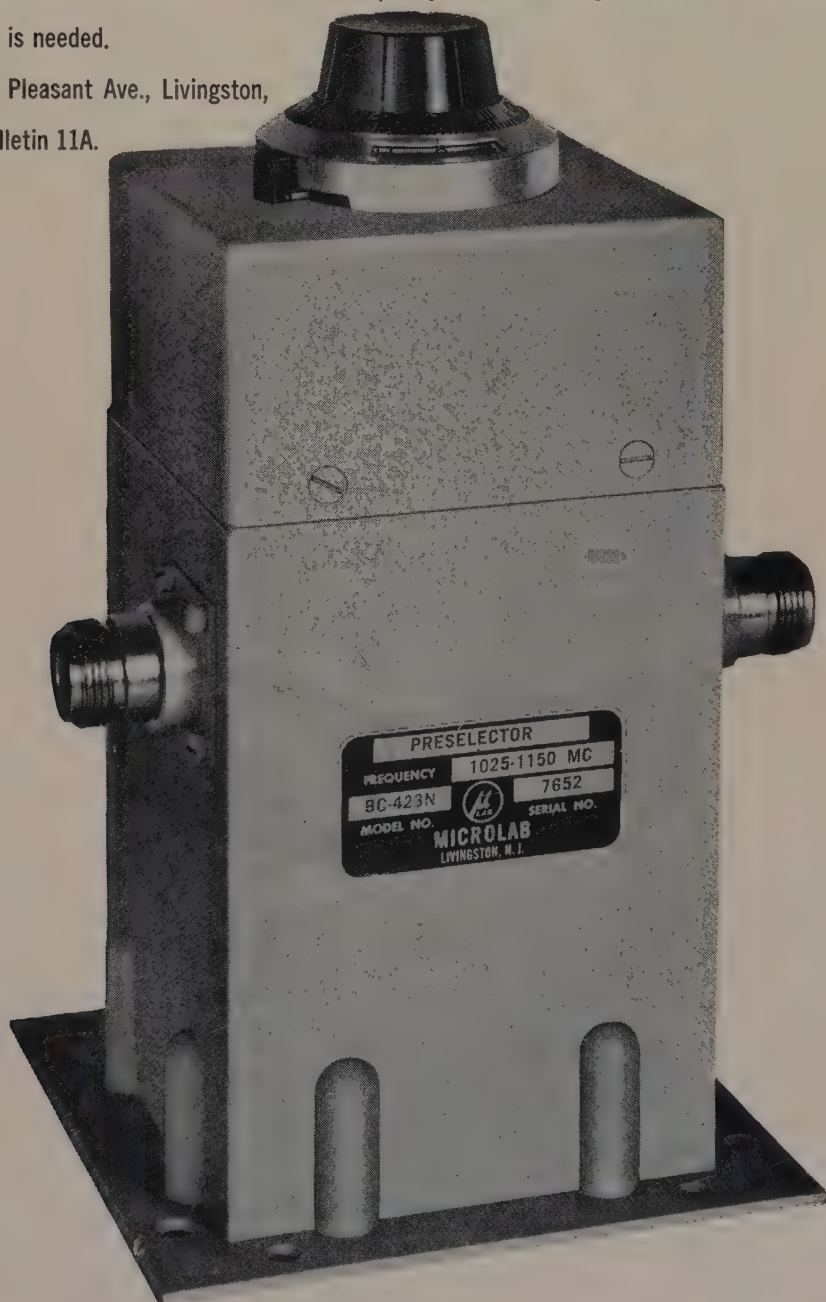
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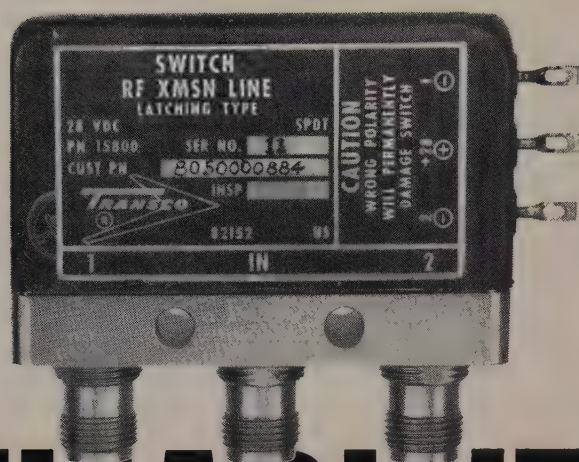
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Industry News

(Continued from page 25)

MOHR APPOINTED MICROWAVE HEAD BY NARDA

Richard J. Mohr has been appointed Microwave Department Head of the Narda Microwave Corp., Mineola, N. Y., William Bourke, president, has announced.



MOHR

Mr. Mohr has an extensive background in microwave engineering, having worked for more than nine years for the Naval Material Laboratory, Brooklyn, N. Y., Airborne Instruments Laboratory, Fort Monmouth, N. J., and recently as Microwave Section Head at the Microwave Dynamics Corp., Plainview, N. Y.

He obtained his BSEE in 1952 from the College of the City of New York and his MSEE in 1957 from the Polytechnic Institute of Brooklyn. He is a member of the IRE.

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PARAMAGNETIC RESONANCE CONFERENCE TO BE HELD IN JERUSALEM

The First International Conference on Paramagnetic Resonance will be held at the Hebrew University of Jerusalem, Israel, during July 16—20th, 1962. The conference is sponsored by the International Union of Pure and Applied Physics.

Topics to be covered are: paramagnetic Resonance of Transition Elements; Double Resonance ENDOR Experiments; theoretical advances in Energy Level Calculations; Resonance Spectra of Point Defects and Radiation Centers in Single Crystals; Spectra of Ion Pairs; Relaxation Phenomena and Line Shape Correlation with Paramagnetic Relaxation Experiments; Correlation of Paramagnetic Resonance Spectra with Optical Spectra; Advances in Experimental Techniques.

The Organizing Committee for the Conference is A. Abragam, Commissariat à l'Energie Atomique, France; B. Bleaney, the Clarendon Laboratory, England; J. Feher, University of California; C. J. Gorter, Kamerlingh Onnes Laboratorium, Holland; C. Kittel, University of California; W. Low, the Hebrew University of Jerusalem; M. H. L. Pryce, University of Bristol, England and J. H. Van Vleck, Harvard University.

Abstracts of about 200 words should be sent to W. Low, Conference Secretary, Hebrew University of Jerusalem, Israel, by February 1, 1962. For further information contact Mr. Low.

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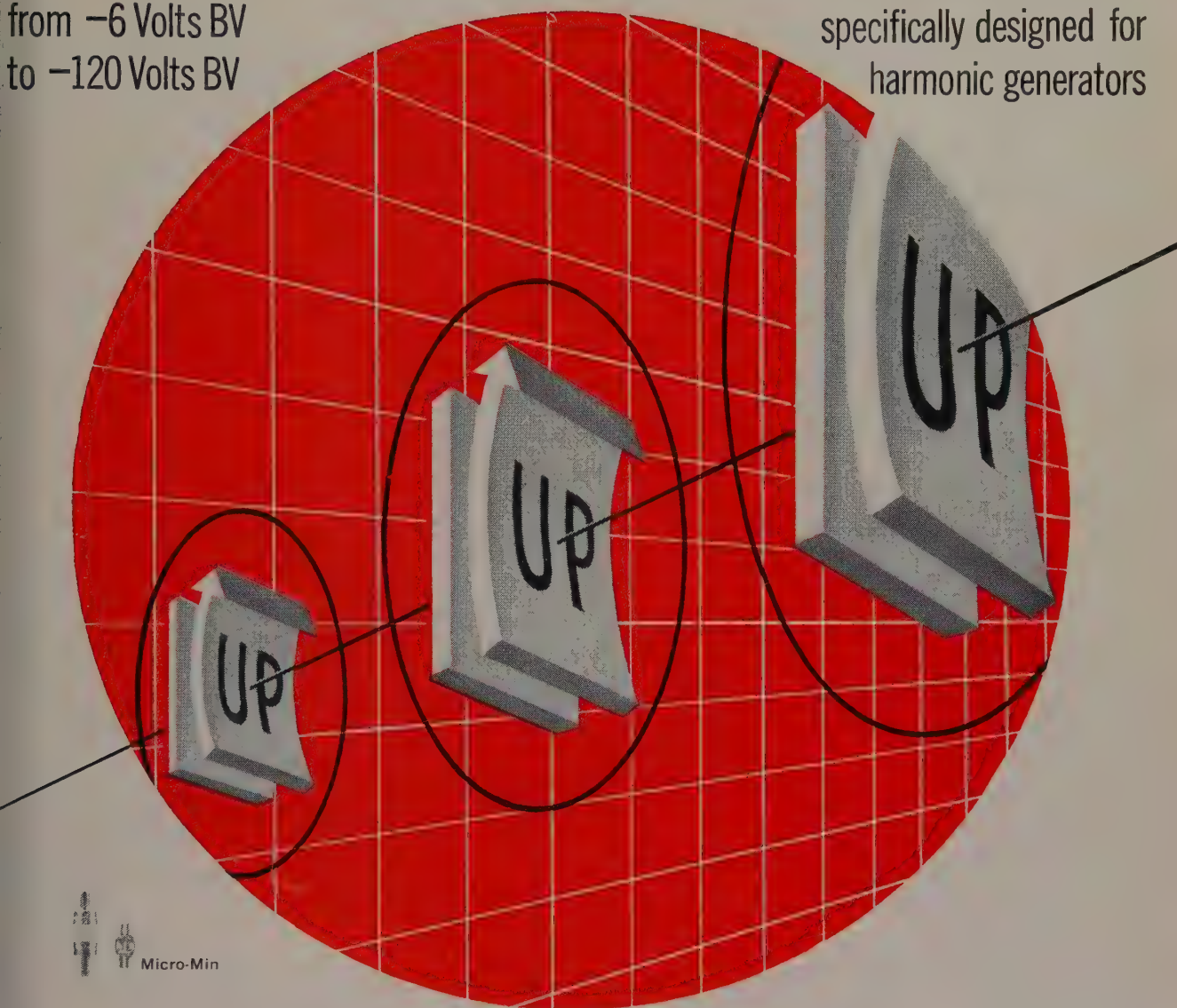
(Continued on page 38)

the microwave journal

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Epitaxial Varactor techniques, pioneered and improved by Sylvania, now make it possible to maintain high-Q even at increased breakdown voltages. Sylvania's D4200-D4270 series Epitaxial Silicon Varactors are specifically designed for service in harmonic generators, offering exceptional power-handling capabilities and conversion efficiencies. Each D4200 varactor is hermetically sealed in a standard ceramic double-ended cartridge designed to meet military environmental conditions.

TYPE*	BV (Volts)	Max f_{co} available in series (-6 volts)
D-4200 (A-K)	6	140 KMC
D-4210 (A-K)	15	140 KMC
D-4220 (A-K)	24	140 KMC
D-4230 (A-J)	30	120 KMC
D-4240 (A-H)	45	100 KMC
D-4250 (A-F)	60	80 KMC
D-4260 (A-C)	90	50 KMC
D-4270 (A)	120	30 KMC

*Also available in Sylvania's Micro-Min package as D-4300 series.

For the complete story on how Sylvania Epitaxial Silicon Varactor Diodes can help upgrade the performance of your microwave equipment, contact your Sylvania Sales Engineer, Sylvania franchised Semiconductor Distributor—or write today for the new "Sylvania Microwave Diode Product Guide." Semiconductor Division, Sylvania Electric Products Inc., Dept. 3512, Woburn, Massachusetts.

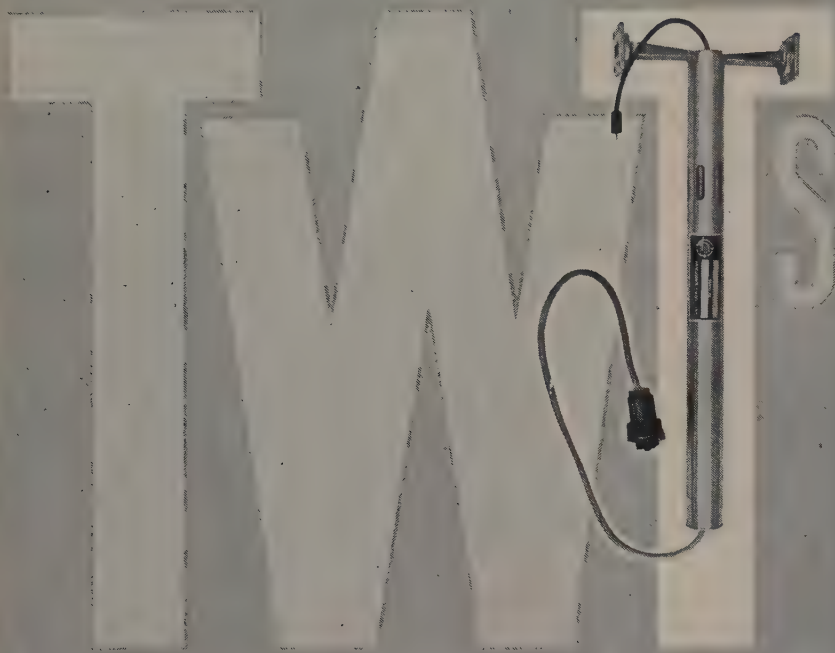
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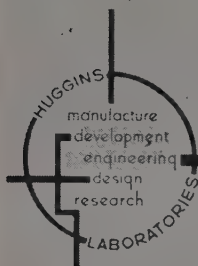


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Industry News

(Continued from page 36)

HAGGERTY NAMED PRESIDENT OF IRE

Patrick E. Haggerty, president and rector of Texas Instruments Inc., has been elected president for 1962 of the Institute of Radio Engineers, Inc. The announcement was made by the institute's Board of Directors at a meeting in November in New York City. Mr. Haggerty succeeds Lloyd V. Berkner, president of the Graduate Research Center of the Southwest Dallas, Tex. as head of the international society of 93,000 electronics engineers and scientists.

Also elected were two vice presidents, one representing overseas countries. In 1962, André M. Angot, technical director of Telecommunications Radioelectriques et Telephoniques, Paris, France. Mr. Angot succeeds Franz Ollendorff, Research Professor at the Technion-Israel Institute of Technology, Haifa, Israel.

Representing North America will be A. Hunter, president of Hunter Manufacturing Co. and Research Professor at State University of Iowa, both in Iowa City, Iowa. Mr. Hunter succeeds J. Byrne, manager of the Riverside Research Lab., Motorola, Inc., Riverside, Cal.

Elected as Directors for the 1962-1963 term are G. K. Teal, assistant vice president of Research and Engineering, Texas Instruments, Inc., Dallas, Texas and A. Woonton, director of the Eaton Electronics Research Lab., McGill University, Montreal, Canada.

Regional Directors elected for 1962-1963 are as follows: Region 1—F. Willenbrock, Associate Dean of Engineering, Harvard University, Cambridge, Mass.; Region 3—M. R. Briggs, manager of Communications and Control Engineering, Westinghouse Electric Corp., Baltimore, Md.; Region 5—W. B. Bruene, Collins Radio Co., Cedar Rapids, Iowa; Region 6—D. K. Reynolds, Professor, Electrical Engineering Dept., University of Washington, Seattle, Wash.

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NEW FINANCING ARRANGEMENTS AND THREE OUTSIDE DIRECTORS AT NARDA

New financing arrangements totaling \$500,000 and the election of three outside directors were announced today by William A. Bourke, president, The Narda Microwave Corp., Plainview, New York.

The financing was placed privately by Harriman Ripley & Co., Inc. with Gulf Southwest Capital Corp., Houston, Texas. Negotiations were made on the basis of 50,000 shares of Narda common stock, \$4 a share, and a \$300,000 note which matures in seven years. Warrants for 50,000 shares, at \$6 a share, will expire currently with payments on the note, the first installment of which becomes due in 1963.

"The equity capital and long-term loan will enable Narda," Mr. Bourke said, "to improve its working capital and expand its operations."

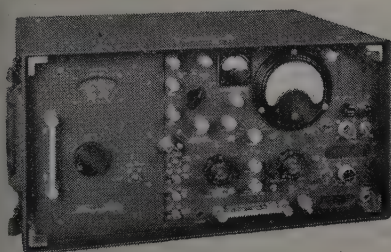
(Continued on page 40)

the microwave journal

THE ONLY SIMPLE FORMULA FOR

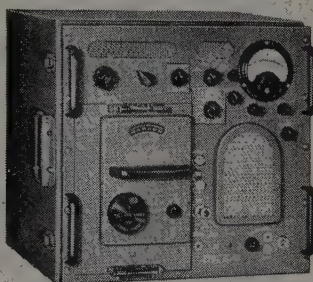


INTERFERENCE MEASUREMENTS



LOW FREQUENCY • Model NF-105

14 KC-1000 MC



HIGH FREQUENCY • Model NF-112

1000 - ~~10,000 MC~~

ENTIRE
FREQUENCY
RANGE

14 KC - ~~10 KMC~~

Through years of hard field use Model NF-105 has acquired an outstanding reputation as a noise and field intensity meter for the frequency range from 150 kilocycles to 1000 megacycles. The versatility of this instrument has now been expanded through the introduction of a new tuning unit extending its coverage down to 14 kilocycles. What is more, this unique measuring equipment has been joined by Model NF-112 which covers the frequency range from 1000 to ~~10,000 megacycles~~. The same simplicity, accuracy and speed of operation and reliability of performance which made Model NF-105 so successful have been designed into Model NF-112. Each instrument uses an impulse generator as its calibrator; each combines in one basic unit the components common to all frequency ranges, including the power supply, calibrator, attenuators and metering circuits. All frequency determining components and circuits are contained in plug-in tuning units. Model NF-112, incidentally, uses one single antenna for the entire range from 1000 to 10,000 megacycles. You save considerably in SIZE, WEIGHT and COST by letting these two instruments do your entire interference measuring job from 14 KC all the way up to ~~10,000 MC~~.

15,000 MC

15 KMC

15,000 megacycles

15,000 MC

Approved for testing to 10 KMC under Specifications MIL-I-11748, MIL-I-6181D, Category A and MIL-I-26600, Category A.

For complete technical information,
send for Catalog 614.

Plan to attend our next seminar on interference
instrumentation. Details upon request.



EMPIRE DEVICES, Inc.

AMSTERDAM, NEW YORK

VICTOR 2-8400

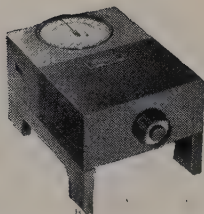
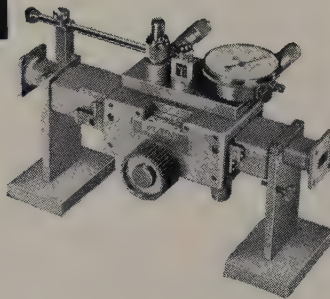
MANUFACTURERS OF: FIELD INTENSITY METERS • DISTORTION ANALYZERS • IMPULSE GENERATORS • COAXIAL ATTENUATORS • CRYSTAL MIXERS

Precision Measurement Demands

QUALITY MICROWAVE

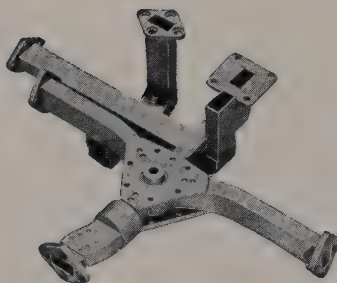
instruments

ATTENUATORS
SLOTTED LINES
WAVEGUIDE COUPLERS
TERMINATIONS
FREQUENCY METERS
PHASE SHIFTERS
DETECTOR MOUNTS
PRECISION TUNERS
NOISE SOURCES
TRANSITIONS
GAIN HORNS
WAVEGUIDE SWITCHES



and components

MIXERS
FILTERS
ANTENNAS
DIRECTIONAL COUPLERS
WAVEGUIDE TEES
DETECTOR MOUNTS
DELAY LINES
HYBRIDS
POWER DIVIDERS
COMPLEX BENDS
MODULATORS
PRESELECTORS



Consult Waveline in order to achieve maximum compliance with your complex waveguide requirements. Standard instruments and special components are available.

WAVELINE INC.

CALDWELL, NEW JERSEY

Phone: CApital 6-9100

TWX Caldwell, N. J. 703

Circle Reader Service Card 28

Industry News

(Continued from page 38)

further its product line of precision components and test equipment for microwave and ultra high frequency communications systems."

The new directors were elected at a special meeting of Narda's board of directors, following the company's annual meeting of shareholders in Plainville, Conn. They are Charles M. Block, vice president and Daniel R. Mahoney, assistant vice president, Gulf-Southwest Capital Corp. and Peter M. Moffitt, an associate of Harman Ripley & Co., Inc.

Mr. Block was senior partner of J. Block & Co., Houston, certified public accountants. Prior to joining Gulf-Southwest Capital Corp., Mr. Mahoney worked with the Baroid Division of National Lead Co. as Coordinator of Special Projects in the field of corporate acquisition. Mr. Moffitt was Executive Vice President of Connecticut Development Credit Corp. of Meriden.

The four other members of Narda's board have been directors since 1957 when the company was founded. They are Dr. John C. McGregor, Chairman, Mr. Bourke, Stuart D. Casper and James E. McFarland.

— m w j —

AIEE AND IRE OFFICIALS CONFER ON MERGER



Haggerty (left) and Chase Confer Plans to Consolidate.

P. E. Haggerty, president-elect of the 90,000 member Institute of Radio Engineers, and Warren H. Chase, president of the 70,000 American Institute of Electrical Engineers, have conferred on first steps to consolidate their organizations into an international engineering society.

The boards of directors of AIEE and IRE have appointed a committee to study the question and to make a report by February 15, 1962. The plan will be submitted to the membership of both organizations. If approved, target date for "consolidation" is January 1, 1963.

Mr. Haggerty is president of Texas Instruments, Inc., Dallas, and Mr. Chase is vice president of the Ohio Bell Telephone Company.

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(Continued on page 42)

the microwave journal

REXOLITE® 1422

COPPER-CLAD DIELECTRIC WILL BOOST
THE PERFORMANCE OF YOUR STRIP LINES

12
FACTS

BACK THIS
PROMISE

A TEN-SECOND
GLANCE AT THIS
CHART WILL SHOW
YOU HOW COPPER-
CLAD REXOLITE
1422 MEASURES
UP IN EVERY
RESPECT TO THE
IDEAL CRITERIA
FOR STRIP LINE
DIELECTRICS.

PROPERTY	IDEAL CRITERIA FOR STRIP LINES	REXOLITE 1422 PROPERTIES
Dissipation Factor	0.001 or less	0.0007
Dielectric Constant	Between 2 and 3 with ± 0.05 tolerance Must be homogeneous and isotropic	2.55 ± 0.01 Meets requirement
Thickness Variation	$\pm .002''$ to $\pm .004''$	Meets requirement
Coefficient of Thermal Expansion	As close to that of copper as possible	Slight warpage after processing, but with no adverse effects
Bond Strength	Must bond well to copper. 5# min; 8-10# average	Meets requirement
Solder Resistance	Withstand 440-450°F for 10 seconds	Meets requirement
Mechanical Strength	Rigid, with high mechanical strength	Meets requirement
Deformation	Must not permanently deform under loads up to 2000 psi at temperatures up to 200°C	Meets requirement
Processibility	Ability to be photo-etched by standard techniques. Easily machined (milled, ground, drilled, tapped) to close tolerances	Meets requirement
Radiation Resistance	Ability to withstand radiation with minimum change in operating characteristics	Meets requirement
Sheet Size	Large enough to provide for most required components.	Standard size sheets 10" x 10" in $\frac{1}{8}''$ to $\frac{1}{4}''$ Other sizes available on special order
Price	Economical—both in original price and processing cost.	Equal to or less than equivalent competitive materials

ANOTHER REXOLITE 1422 PLUS

Our strip line problems are welcomed by the broad dielectric engineering department at Brand-Rex. This team of specialists have worked cooperatively with design engineers from many of America's leading electronics firms to boost the performance of strip lines with REXOLITE 1422.

Without obligation, you are invited to write for engineering help, samples and complete technical information about... **REXOLITE 1422**

COPPER-CLAD DIELECTRIC



DIVISION OF

American ENKA Corporation

Dept. R, 37 Sudbury Road, Concord, Massachusetts

Phone: EMerson 9-9630

Vinyl, Teflon, Neoprene, Nylon, Polyethylene Wire and Cable —
Electrical Tubing and Sleeving — Turbo® Coaxial Cables

are

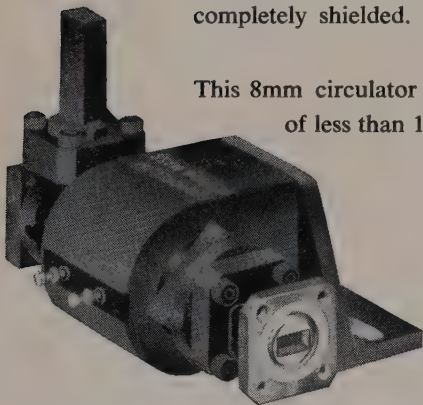
YOU in MILLIMETERS YET?

WE are, with circulators, isolators, modulators, and switches. In fact, Ferrotec has the most complete line of millimeter ferrite devices in the industry — covering bands to 75 Kmc.

This miniature isolator, for example, for 8mm wavelengths, provides 20db isolation for 1db loss over a 6% band, all in 1½" length, 1" diameter, 2 oz. in weight, and completely shielded.



This 8mm circulator switch offers switching times of less than 1 usec, over a 3% bandwidth.



Here are typical standard millimeter ferrite devices, from our line of nearly 50 different stock-design components — quickly available to you!

Type	f ₀ (Kmc)	Bandwidth	Model
Circulator switch	70	5%	R-227LS
Tee circulator	70	3%	T-153L
Circulator	70	3%	R-224L
Circulator switch	52.5	6%	R-307LS
Circulator switch	35	6%	R-300LS
Isolator	35	6%	R-343L
Circulator switch	33	3%	R-222LS
Circulator switch	24	6%	R-214LS

Ferrotec, specialists in ferrite components, offers the most comprehensive line — from 250 mc to 75 Kmc — in the industry. Do you have the complete catalog?

FERROTEC INC.

217 CALIFORNIA STREET • NEWTON 58, MASS.

Industry News

(Continued from page 40)

PROFESSIONAL GROUP ON MILITARY ELECTRONICS CALLS FOR PAPERS

The 6th National Convention on Military Electronics (MIL-E-CON 1962) will be held at the Shoreham Hotel, Washington, D.C., on June 25, 26, and 27, under the sponsorship of the Professional Group on Military Electronics of The Institute of Radio Engineers. Ralph I. Director, Government Project Section, Westinghouse Air Brake Co., Falls Church, Va., is Convention President for MIL-E-CON 1962.

Papers presenting original work in military electronics are invited for this meeting. Suggested topics include, but are not limited to the following: Current Problems of Space Technology; Space Electronics; Ranging and Tracking; Electric Propulsion; Data Handling Systems; Molecular Electronics and Systems; Guidance and Control; Inertial Systems; Reconnaissance Systems; Communication Systems; Operational Analysis; Reliability.

The technical program will include classified and unclassified sessions, the Air Research and Development Command sponsoring the classified sessions. Unclassified and bound *Proceedings* of the convention will be available at the meeting.

Prospective authors are requested to furnish the following information, not later than February 1, 1962: three copies of a 750-word unclassified abstract of the proposed paper, plus the name and position of the author and the name and address of his company or organization; three copies of a biographical sketch of the author, including education, experience, memberships in professional societies, honors, and publications.

Each author must obtain the appropriate military and company clearances for the abstract.

Send abstracts to:

Mr. John J. Slattery
F316
The Martin Company
Baltimore 3, Maryland

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MICRO LINK LEASES ADDITIONAL SPACE

Further expansion of the activities of the Micro Link Corp. has necessitated the leasing of additional space at Copiague, L. I., N. Y.

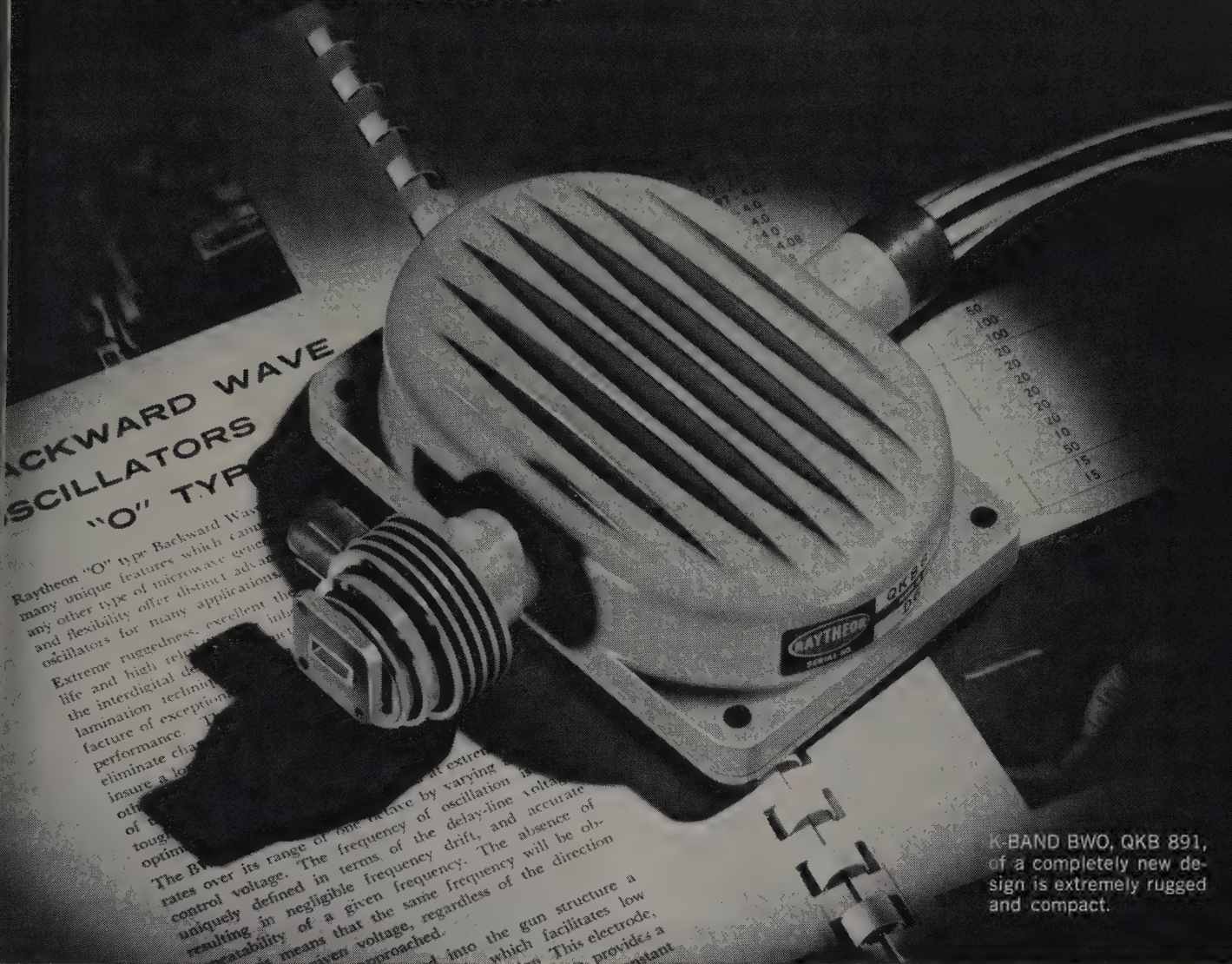
The Micro Link Corp., a wholly owned subsidiary of LEL Inc., is engaged in the development and manufacture of low power point-to-point microwave links for use at frequencies allocated to the business services.

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(Continued on page 44)

the microwave journal

ANOTHER ADVANCED MICROWAVE TUBE DEVELOPMENT
FROM RAYTHEON'S SPENCER LABORATORY



K-BAND BWO, QKB 891, of a completely new design is extremely rugged and compact.

New K-band O-type BWO's extend Raytheon compatible line to 26.5 kMc

Advanced design provides 40 mW minimum power output in extremely rugged and compact package.

Size and weight of these two new Raytheon backward wave oscillators are barely half that of units now in use.

The QKB 890 and QKB 891 are designed for such applications as swept local oscillators in ECM receivers and test equipment, driver tubes in frequency diversity radars, and pump tubes for broadband parametric amplifiers. Both tubes utilize PM focusing and have grids for low-voltage pulsed operation. For equipment designs requiring close mounting, only two-inch spacing between tubes is necessary.

Write today for detailed technical data or application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

TYPICAL OPERATING CHARACTERISTICS

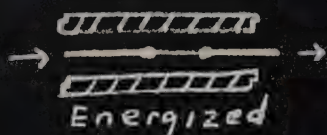
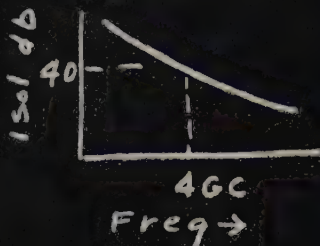
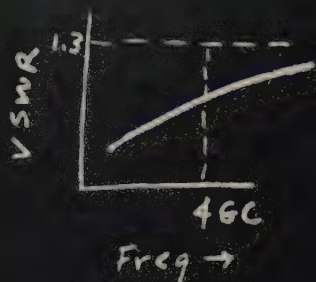
	<u>QKB 890</u>	<u>QKB 891</u>
Frequency Range	12.4-18 kMc	18-26.5 kMc
Power Output	40-180 mW	40-180 mW
Delay Line (tuning)	400-1270V	600-2100V
Anode Voltage (fixed)	125V	150V
Cathode Current	17-21 mA	21-32 mA
Filament Voltage	6.3 Volts	6.3 Volts
Waveguide Coupling..	RG91/U	RG53/U

RAYTHEON

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

Another QUANTATRON Chalk Talk



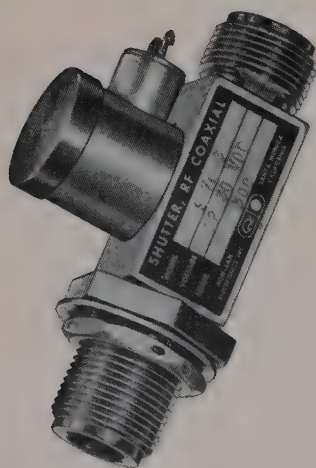
PROTECT CRYSTALS WITH THIS TINY COAX SHUTTER

Add or remove 40 db of isolation with a wink of this microwave eye—operates in 6 milliseconds. Small and rugged, the DON-LAN Model S-70 Coaxial RF Shutter is designed to function reliably in extreme environments of shock, vibration and temperature. This remotely-operated device protects crystal diode and other receiver components against burnout or damage.

These miniature S-70 shutters are but one of the unique DON-LAN family of microwave products. Write for details. Also ask about switches, tuners, attenuators and other coaxial and waveguide system components.

Consult our engineering staff on your microwave problems.

ACTUAL SIZE



Don-Lan Electronics Inc.
a subsidiary of
Quantatron, Inc.
2520 Colorado Avenue
Santa Monica, California
EXbrook 3-0758

Employment opportunities for qualified microwave engineers

Circle Reader Service Card 32

Industry News

(Continued from page 42)

AVIEN APPOINTS SHNITKIN HEAD OF ADVANCED R&D DEPARTMENT

Appointment of Harold Shnitkin as head of Advanced Research and Development, Antenna Division, Avien, Inc., Woodside, N. Y., has been announced by Richard D. Bogner, division manager.



SHNITKIN

Mr. Shnitkin joined Avien in July. In his new post, he will be responsible for search and development of complex phased array designs of the patented Avien-Bogner disc-on-rod antenna systems. A considerable portion of his duties will be in the application of digital computer techniques to the solution of antenna array problems.

Prior to joining Avien, Mr. Shnitkin was Manager of the Advanced Microwave Development Department, W. L. Maxson Corp.

Mr. Shnitkin's experience has been in advanced research and development of electronically scanned antenna array systems, monopulse type tracking antennas, omnidirectional antennas, shaped antenna configurations and ferrite scanned antenna arrays. He is an Associate Professor of Physics at Hofstra College in Hempstead, N. Y. Mr. Shnitkin holds a bachelor's science degree in electrical engineering from Union College and a master of science degree in electrical engineering from Yale University.

— m w j —

ELECTRONIC SPACE STRUCTURES PLANS NEW PLANT

Joseph A. Vitale, President of Electronic Space Structures Corp., West Concord, Mass., announced the construction of a new plant and precision antenna test range in Concord, Mass.

The building is scheduled for completion in February 1962 and will be leased by the company. Electronic Space Structures is a new company that was formed in July, 1961 by a group of engineers and scientists from Lincoln Laboratory, Massachusetts Institute of Technology.

The modern, one-story building will house the company's executive offices and initially will provide an area of 15,000 square feet for the design, development and manufacture of precision antennas and radomes. The antenna test range will be 2000 feet in length and is designed for measurements to astronomical precision. The company expects to provide employment for 100 persons.

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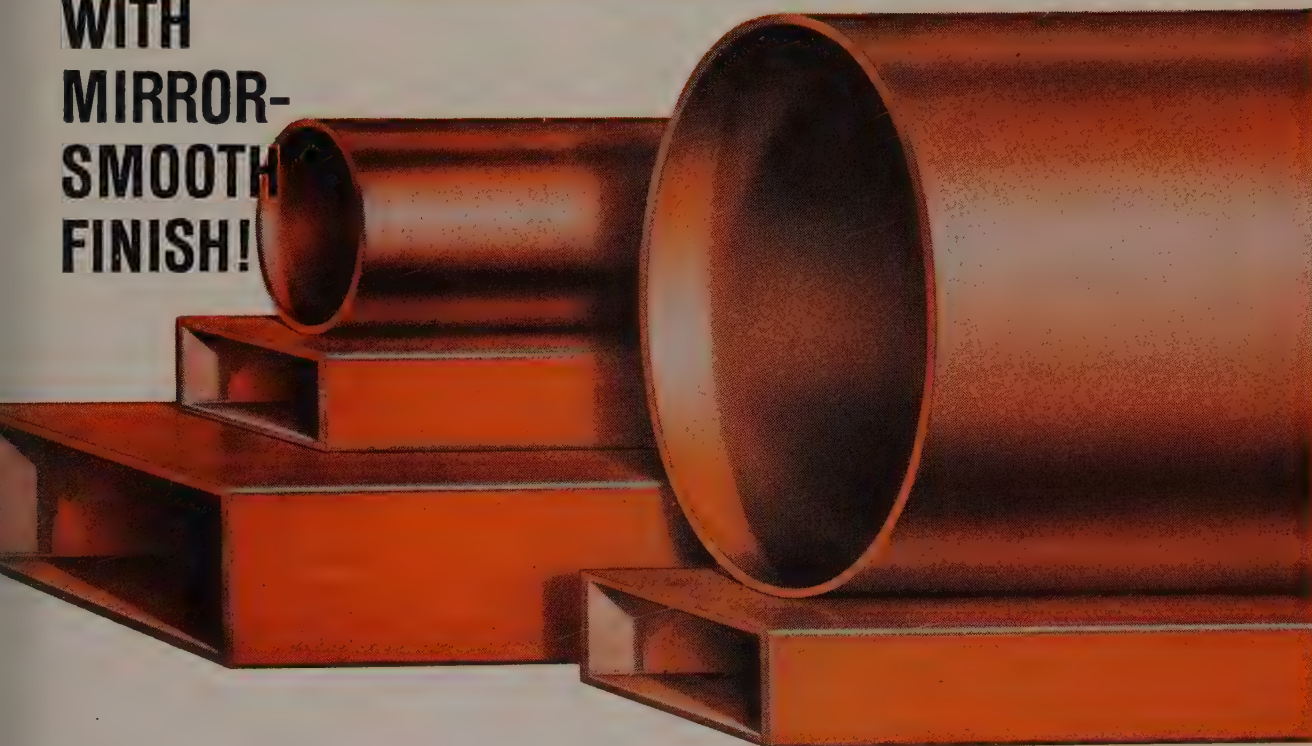
(Continued on page 46)

the microwave journal

**PHELPS DODGE
SEAMLESS
RIGID**

Waveguides

**WITH
MIRROR-
SMOOTH
FINISH!**



Phelps Dodge has expanded its precision-crafted line of waveguides to include circular as well as rectangular seamless shapes. Both types are carefully extruded and individually cold drawn from oxygen-free copper and commercial bronze to closest tolerances.

Through close control of the ID tolerances and surface, Phelps Dodge assures top performance at high fre-

quencies. Phelps Dodge offers the widest variety of standard sizes for both rectangular and circular waveguides. Both types are available in 12-foot stock lengths, and longer lengths on special order. Minimum mill quantity is 500 lbs. per size for oxygen-free copper, and 1,000 lbs. for commercial bronze.

PHELPS DODGE COPPER PRODUCTS

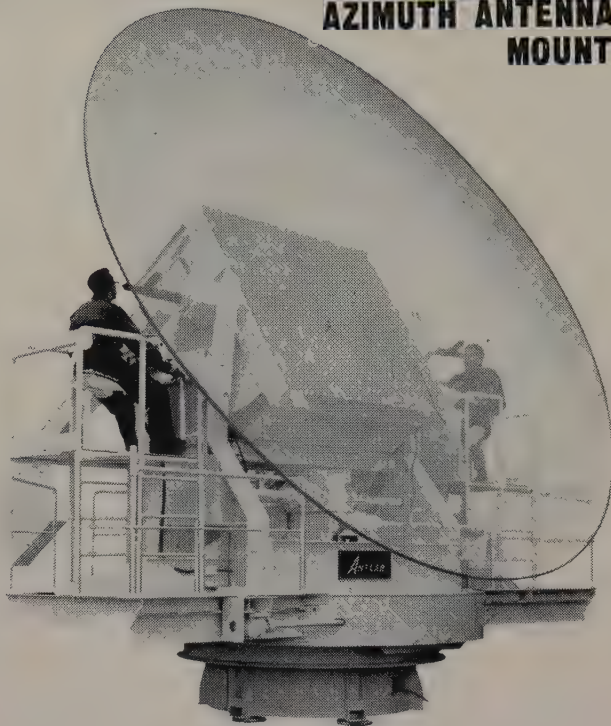
CORPORATION

300 Park Avenue, New York 22, N. Y.



Circle Reader Service Card 33

ANTLAB'S MODEL 3547-40 ELEVATION ON AZIMUTH ANTENNA MOUNT



ANTLAB has designed and manufactured a new and larger antenna mount to augment the company's line of heavy-duty pedestals. It is the Model 3547-40 elevation-on-azimuth mount (pictured above), for accurately positioning large antennas and radio telescopes.

The Model 3547-40 delivers 60,000 footpounds of torque in each axis. Extreme ruggedization of framework and all components permits the mount to support loads of 60,000 pounds while delivering maximum torque. The mount is normally equipped for electro-manual (velocity) control by means of center-off control knobs. However, the unit may be designed for fully automatic (servo) control or for specialized hand-cranking operations (as shown).

A large clearance hole through the center of the azimuth table allows passage of power cables, position circuitry, and other system components. Special extension shafts may be optionally added in elevation to accept counterweights. Thus, the Model 3547-40 antenna mount may be used with many different types and sizes of antennas.

SPECIFICATIONS (Model 3547-40)

Azim. Torque Deliver: 60,000 ft. lbs.
Azim. Torque Withstand: 60,000 ft. lbs.
Elev. Torque Deliver: 60,000 ft. lbs.
Elev. Torque Withstand: 60,000 ft. lbs.
Load: 60,000 lbs.
Azim. Motor: 4 h.p. DC
Elev. Motor: 4 h.p. DC
Azim. & Elev. Accuracy: 0.01°
Azim. Motion: $\pm 175^\circ$ — others available
Elev. Motion: -5° to $+95^\circ$
Max. Azim. Speed: 1/10 rpm
Max. Elev. Speed: 90° in 150 sec.
Table Size: 80" sq.
Over-All Height: 113"
Maximum Base Radius: 74"
Weight: 25,000 lbs + counterweights
Synchro Ratio: 36:1
Power Requirements: Approx. 10KW
Price: \$29,200 (price does not include hand cranks, counterweights, controls or other accessories).

ANTLAB'S Model 3549-40 Antenna Mount is a heavy-duty, three-axis pedestal (polarization on elevation on azimuth) which embodies the same features of ruggedness and design flexibility as the Model 3547-40. This Mount will also support loads of 60,000 pounds while delivering maximum torque in all three axes. Price of the basic unit is \$36,585. Write for complete specifications.

ANTLAB Antenna Range Instrumentation includes: Servo and electro-manually controlled antenna test mounts, tracking systems, model support towers, microwave receivers, pattern recorders, pattern integrators, boresight systems, antenna position indicators, fork-controlled oscillators, anechoic chambers, radome mounts, source positioners, etc. Send for catalog A-161.

ANTLAB, Inc.

6330 PROPRIETORS ROAD, WORTHINGTON, OHIO • TU 5-5396

Industry News

(Continued from page 44)

WATKINS-JOHNSON APPOINTS FOUR TO TECHNICAL STAFF

Dr. Dean A. Watkins, president of Watkins-Johnson Co., Palo Alto, Cal., has announced four appointments to the technical staff to advance company programs in electron devices and electronic systems.

Donald C. Hunceker, formerly in charge of all power tube manufacturing at Varian Associates, will take a management position in the production of high-power traveling wave tubes. An alumnus of the University of Portland, he is a veteran of the U.S. Marine Corps in World War II and Korea.

Rowland W. Haegele will lead production engineering of low-noise tubes. Haegele is a senior member of the IRE and served as chairman of the Salt Lake Station during a period with Eimac's Utah facility. He has a BS from Illinois Institute of Technology and an MS from Stanford University.

James A. Long will work on the development of traveling-wave tubes for use in satellite communication systems. Formerly he was a senior engineer with Sylvania in microwave devices operations at Mount View, Cal. He is a member of the IRE and its Professional Group on Electronic Devices. From 1950 through 1954 he was an electronic technician with the Air Force. He graduated from Oregon State College.

Richard E. Pospisil joins Watkins-Johnson's R & D team in its Systems Division, working initially on airborne jamming equipment and power supplies for active communications satellites. Pospisil has a BS in Electrical Engineering from Iowa State College and has done graduate work at Stanford University and San Jose State College.

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SHANLEY NAMED ASSOCIATE DIRECTOR OF RESEARCH

Appointment of Dr. Thomas J. B. Shanley as associate director of Research has been announced by Donald G. Fink, vice president-research, of Philco Corp., Philadelphia, Pa.

In his new position reporting directly to Mr. Fink, Dr. Shanley will be responsible for staff coordination of Research Division operations.

Dr. Shanley retired with the rank of Colonel last month from the U. S. Army. His most recent military assignment was with the Office of the Joint Chiefs of Staff. His previous positions of responsibility included assignments with Office of the Deputy Chief of Staff for Military Operations, command of the 19th Infantry Regiment during the Korean conflict. From 1950 through 1953, he was chief of the Research Division, R&D Section of the Office, Chief of Army Field Forces.

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(Continued on page 49)

the microwave journal

SPERRY

Microline®

MICROWAVE SOURCES

...TRIUMPHS of VERSATILITY...

62A1

Beam —200 to—4000 v, continuously adjustable. 0 to 150 ma, .01% regulation, 3 mv max. ripple.

Reflector 0 to—1000 v, .01% regulation, 3 mv max. ripple.

Filament 6.3 v, 4 amps, with provision for external filament supply.

Modulation 0 to 250 v, peak to peak, all waveforms.

62A2

Voltage 2.5 to 10 v d c, continuously adjustable

Current 2 amps max.

Ripple 5 mv max.

62A3

Beam —200 to—700 v, continuously adjustable. 0 to 70 ma, 1 v line regulation, 5 mv max. ripple.

Reflector 0 to—1000 v, 0.1% regulation, 5 mv max. ripple.

Filament 6.3 v, 0 to 2 amps.

Modulation 0 to 150 v, peak to peak, all waveforms.

SPECIFICATIONS

Microline Model	Output Frequency GC	Minimum Power mw	Sweep Rate seconds
64S1	2.0- 4.0	60	.01 to 100
64C1	4.0- 8.0	20	.01 to 100
64X1	8.2-12.4	20	.01 to 100

Modulation: Internal grid modulation, 1000 cps or provision for external modulation.

Leveling: Output level controlled from front panel. Provision for external level control for programming output level.

Frequency Scale: Slide rule dial accurate to percent.

Sweep: Linear, with time to 1 percent.

Size: 12¼" x 19¼" x 17¼".

Power: 105 - 125 / 210 - 230 volts; 50 - 60 cps.

Prices: S-Band \$2850.

C-Band \$2850.

X-Band \$2750.



\$1300



\$240



\$550



64X1

KLYSTRON POWER TRIO

- Widest beam power range available.
- Smallest and lightest packages on the market.
- Solves your most critical power requirements — Excellent regulation, low ripple, stable operation.

MICROWAVE SWEEP OSCILLATOR

SWEEP: End points independently adjustable over entire frequency range. Sweep may be from low to high, or high to low frequency. Sweep rates continuously variable in four ranges from .01 to 100 seconds. There is provision for external sweep, dc coupled, to permit frequency programming.

MARKERS: Five separate markers at the start and stop frequencies and any three intermediate points. Markers can be set directly from front panel meter, or readily with an external wavemeter using the unique spot frequency selection feature.

SPOT FREQUENCY SELECTION: Five spot frequencies are available, which are independently selected by the start, stop and three marker settings. The Microline oscillator is a five-frequency, preset signal generator as well as a swept oscillator.

DIVISION OF SPERRY RAND CORPORATION

SPERRY

MICROWAVE ELECTRONICS COMPANY

CLEARWATER, FLORIDA

Microline Instruments • Radar Test Sets • Systems Instrumentation • Solid State Devices and Materials • Microwave Components and Antennas

December, 1961

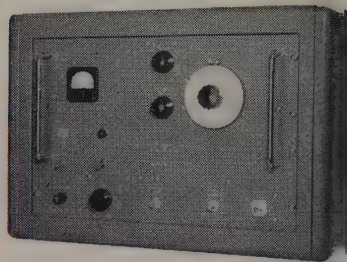
Circle Reader Service Card 55

47

POWER SOURCES, POWER MEASUREMENT

Accurate, fast, versatile

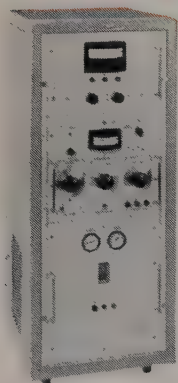
multi-purpose
wide-range
power
sources



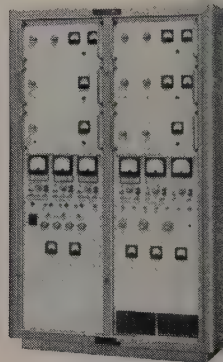
Sierra Model 215 series power sources cover 25 to 1000 mc in four instruments. They permit fast, accurate calibration of bidirectional power monitors

and termination wattmeters, plus medium-power antenna measurement interference measurements and other applications involving high attenuation of input signals. All have a nominal output of 50 watts, with output adjustable from 20% to 100% of rated power. Extreme stability facilitates repetitive or routine measurement, easy to use. Models cover, respectively, 25-50 mc, 50-150 mc, 150-470 mc, 470-1000 mc. \$3,300.00 each.

Plus these instruments for power measurement

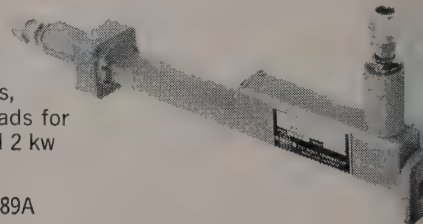


Six accurate, dependable power sources are available in the Model 1223 RF Calibration Test Set, which includes six power sources, six power monitors, power and frequency selector unit, blower unit, control unit and two regulated power supplies. Variable power to 125 watts at rf frequencies of 30, 100, 300, 400, 500 mc, to 60 watts at 1300 mc. Calibrates power-measuring devices to 1% accuracy (0.5% probable accuracy) \$15,000.00.



Sierra calorimeters and mating water loads are available for both waveguide and coaxial applications. Model 290B, accurate to 1%, includes liquid flow controls, self-calibration sources, metering circuits. Dual water loads for balanced measurements include three waveguide models for C, XB and X bands, one coax model, dc to 4000 mc. Model 290B, \$4,500.00.

Sierra Model 190A Calorimeter offers maximum power ranges of 300, 600, 1500 and 3000 watts. It provides a complete measuring system in conjunction with Model 186 Coaxial Liquid Cooled Loads, to 1000 watts, dc to 4000 mc; Model 187 series waveguide water loads for SL, S, C, XB and X bands, with average power limits 20, 10, 5, 3 and 2 kw respectively. Model 190A, \$860.00. Loads, \$275.00 to \$600.00.



For applications where a complete Model 190A is not required, Sierra offers Model 189A Differential Thermopile for use with 186 or 187 water loads. \$85.00.

Look to Sierra for your power source and power measurement requirements. Write or call your nearest Sierra representative or contact us direct for full information.

Data subject to change without notice. Prices f.o.b. factory.

Sierra SIERRA ELECTRONIC CORPORATION

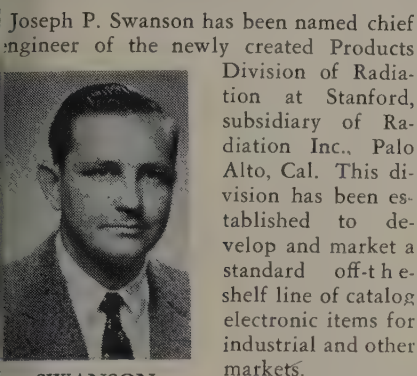
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(Continued from page 46)

SWANSON TO HEAD RADIATION AT STANFORD PRODUCTS DIVISION



SWANSON

Joseph P. Swanson has been named chief engineer of the newly created Products Division of Radiation at Stanford, subsidiary of Radiation Inc., Palo Alto, Cal. This division has been established to develop and market a standard off-the-shelf line of catalog electronic items for industrial and other markets.

Swanson, a specialist in commercial applications of high energy electronic systems and components, joined the company in 1954.

He stated that the first product to be introduced by the division is a crowbar logic circuit. This device protects high power tubes from gas bursts and other malfunctions by instantaneously shorting out the associated power supplies and capacitor banks. "Additional products will be announced and placed on the market by the end of the year," he said.

Swanson earned a master of science degree in electrical engineering at the graduate school of Stanford University after completing his undergraduate studies at Antioch College, Ohio. He is a member of the IRE, active in the professional groups on instrumentation and engineering management, and is a past chairman of the IRE's Professional Group on Medical Electronics.

— m w j —

MICROWAVE ASSOCIATES APPOINTS WAVEGUIDE R&D MANAGER

Microwave Associates, Inc., Burlington, Mass., announces the appointment of Stanley L. Johnson as a Research and Development Project Manager in the Waveguide Systems Division. Mr. Johnson will head a group of engineers currently engaged in Microwave Associates' research programs for design of frequency multipliers and parametric amplifiers.

Prior to joining Microwave Associates, Mr. Johnson was associated for seven years with the Wayland Laboratory of Raytheon Company, Wayland, Mass. From 1958 to 1961 he served as a group leader with Raytheon in the design of microwave solid-state devices such as C-band parametric amplifiers and highly efficient frequency multipliers.

Mr. Johnson received his Bachelor of Arts degree in 1948, his B.S. degree in electrical engineering in 1949, and his masters degree in physics in 1954, all from Columbia University. He is a veteran of the U. S. Navy and served on active duty in 1945-1946 and again in 1951-1952.

He is a member of the Institute of Radio Engineers and Tau Beta Pi.

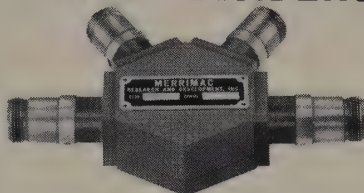
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MERRIMAC

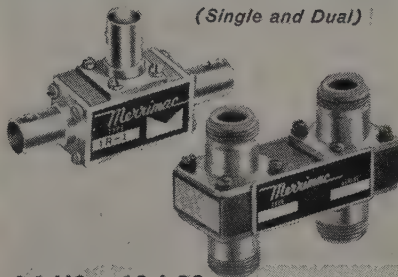
COMPONENT CAPABILITIES

Hybrid Unequal-Split
Fixed and Variable
(with in-phase or quadrature outputs)
POWER DIVIDERS



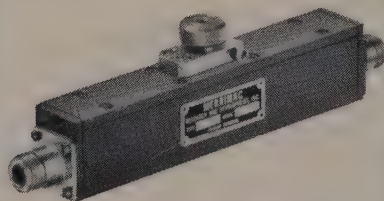
0.1 MC — 12.4 GC

DIRECTIONAL COUPLERS
(Single and Dual)



0.1 MC — 12.4 GC

Variable
PHASE SHIFTERS



0.1 MC — 12.4 GC

Balanced
MIXERS



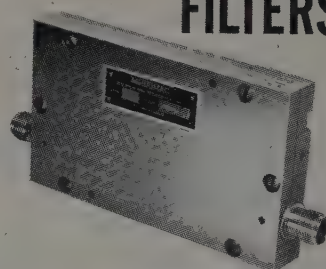
0.1 MC — 12.4 GC

Slide Screw
TUNER

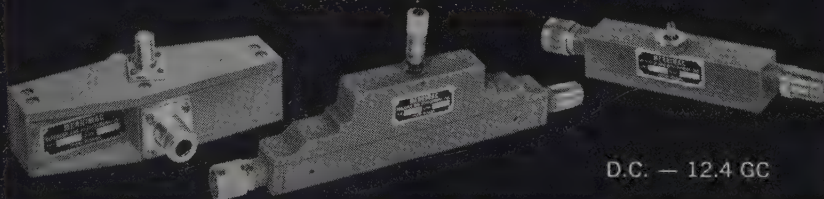


1.0 GC — 8.0 GC

Custom-engineered
FILTERS



ATTENUATORS



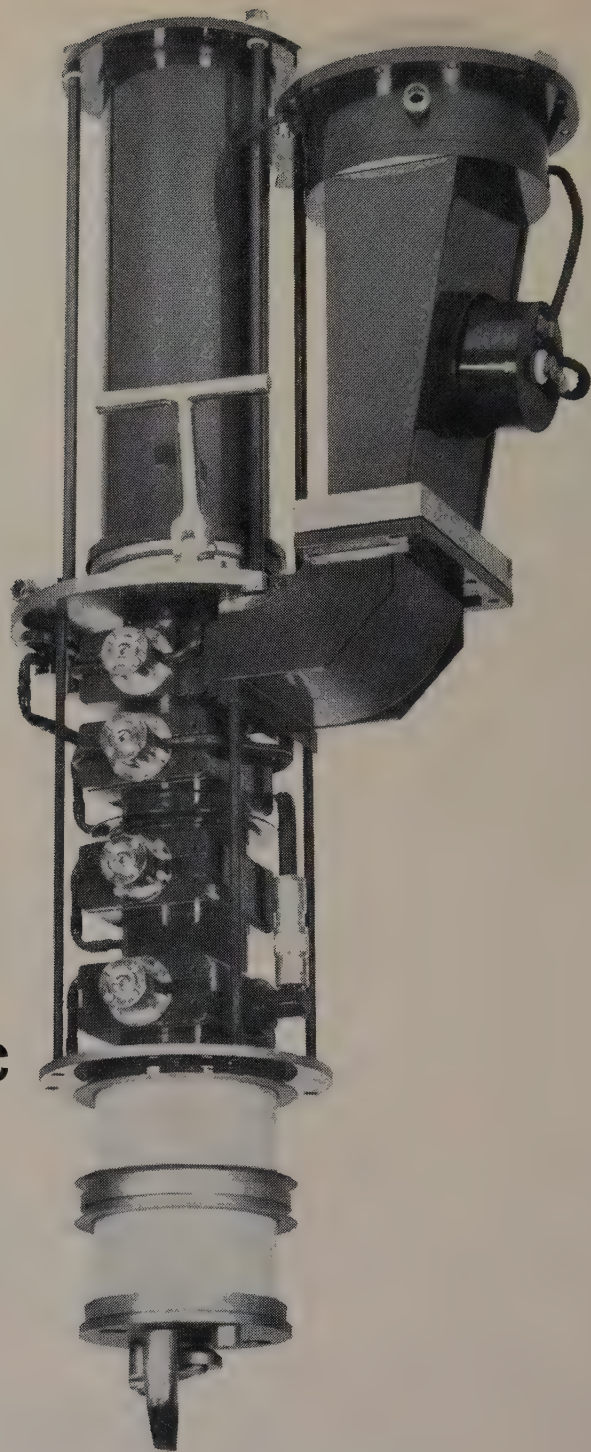
D.C. — 12.4 GC

Further data on items shown above sent on request.

Our capabilities in development and production are available for the solution of your problems involving both conventional and novel waveguide and coaxial components.



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RESEARCH AND DEVELOPMENT, INC.
517 Lyons Avenue, Irvington 11, N. J.



20KW CW AT 2KMC

New Eimac 4KM70SJ klystron doubles CW power available at S-band.
And offers all these outstanding features for scatter and space communications:

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| 1. 20 kilowatts CW | 7. One fixed magnet supply |
| 2. Tunable — 1700-2400Mc | 8. High efficiency at both 10 and 20 KW |
| 3. Minimum 3db bandwidth: 12Mc | 9. Built-in titanium vacuum pump |
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| 5. Meets AN/FRC-56(v) specifications | 11. Four integral cavities |
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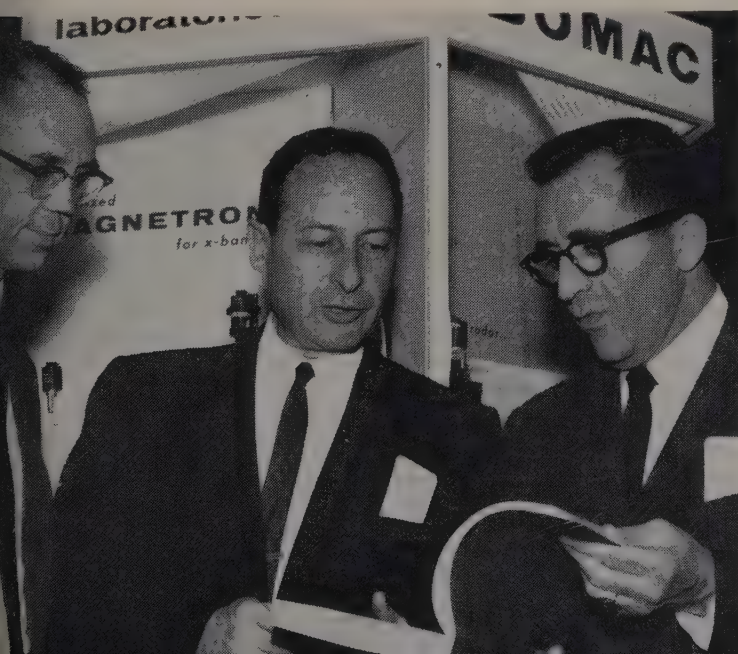




Managing Editor Jim Hughes presents the first copy of *the microwave engineers' handbook and buyers' guide* to Marlene Schmidt, Miss Universe of 1961. Miss Schmidt was presented *the handbook* to assist her in her engineering work when she returns to Germany. She appeared at NEREM on behalf of North American Electronics, Inc., West Lynn, Mass.

the microwave journal Visits NEREM

Editor-in-chief Ted Saad, (right), shows *the handbook* to Martin E. Packard, (left), Director of Research, Instrument Division, Varian Associates, and Herbert A. Finke, (center), Vice President and General Manager, Bomac Laboratories, Inc., a Varian subsidiary.



Miss Universe smiles her approval of *the handbook*.

(Continued)



Upper left, Joseph F. Bozzelli, (left), Marketing Manager, Red Bank Division, Bendix Corp., shows a through port circulator to Editor-in-Chief Ted Saad.

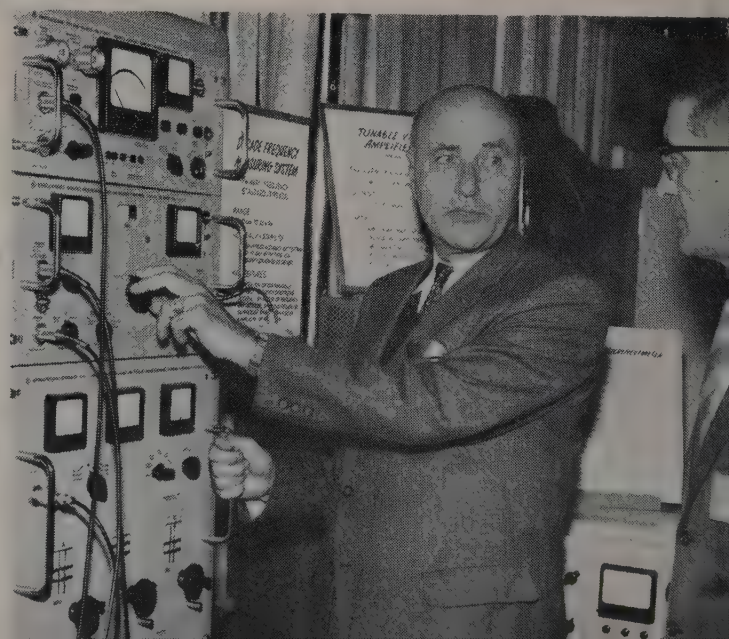
Upper right, Managing Editor Jim Hughes, (left), and Jean Jolkovski, Director of Marketing, Applied Research Inc., discuss a UHF network.



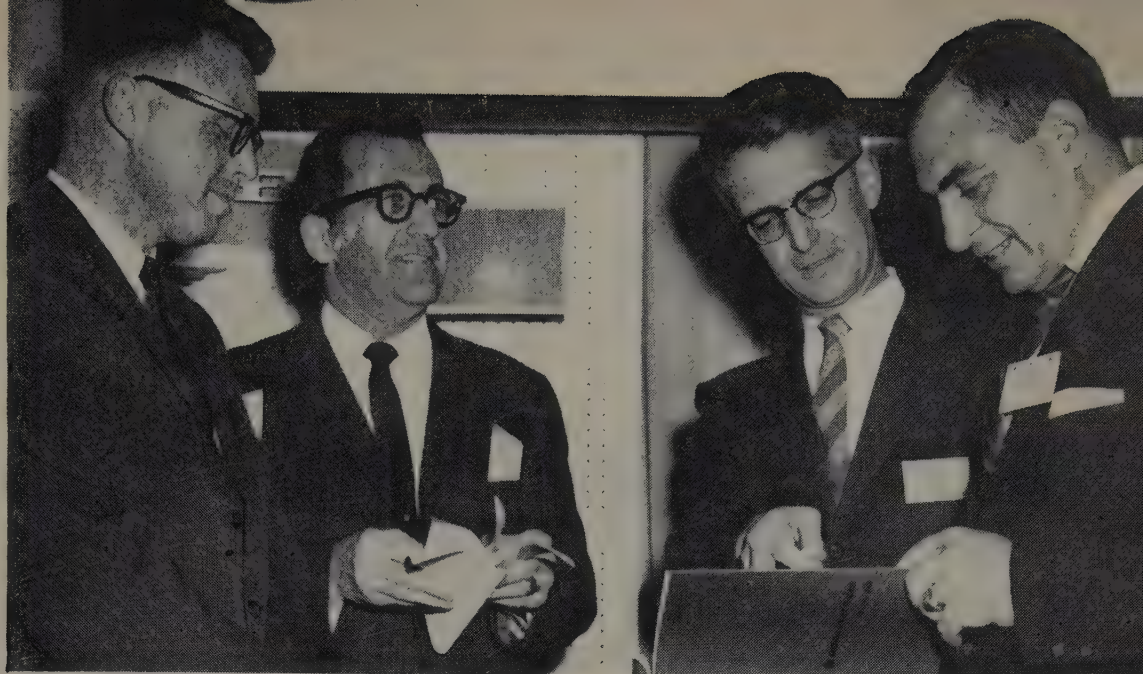
Left, Ted Saad, (left), Dr. Peter Lacy, (center), Vice President, Wilttron, and Jim Hughes pause at a technical instrument display.

Lower left, (left to right), Editor Gene Hodge, Alcatel, and J. Kirkaldy, Assistant Sales Manager, Industrial Products Division, Jerrold Electronics Corp., and Douglas R. Vining, Sales Manager, Defense and Industrial Division, Technical Appliance Corp., take a quick look at the microwave engineers' handbook and buyers' guide.

Lower right, Rudolf Feldt, (left), President, Rohde Schwarz Sales Co., Inc., explains the operation of a decade frequency measuring system to Jim Hughes.



Right, Editor-in-chief Ted Saad, (second left), Managing Editor Jim Hughes, (second right), and Editor Gene Hadge, (right), visit Robert D. Freedman, Sales Manager, American Electronic Laboratories, Inc., at the AEL booth.



Above, Ted Saad, (right), shows a copy of *the handbook* to Paul G. "Tiny" Yewell of Yewell Associates.



Upper right, Assistant Managing Editor Mike Leonard, (left), and William A. Bourke, President, Narda Microwave Corp., examine a copy of *the handbook*.

Right, C. J. Lahanas, (left), Assistant Advertising Manager, and Richard Jokinen, (center), both of General Radio Co., discuss a connector display with Jim Hughes.



EIMAC CREATES ACCESSORY PRODUCTS DIVISION

Eitel-McCullough, Inc., San Carlos, Cal., manufacturers of electron-power tubes,



HAEGELE

has established a new division to be known as the Accessory Products Division, it was announced by Richard T. Orth, vice president, operations. This division brings together existing operations in the development and manufacture of amplifier klystron circuitry, water loads and power-grid tube sockets.

Eimac's Accessory Products Division will develop additional non-vacuum accessory products such as power-grid tube cavities and other items physically related to electron-tubes. The new division makes a total of five product divisions for the firm; others being the Power Grid Tube Division, High Power Microwave Division, Microwave Division and Parts Division.

Jerald R. Haegele has been named manager of the newly created Accessory Products Division, according to Orth. Haegele joined Eimac in 1956 in an administrative capacity in research and development. Prior to his present appointment Haegele was manager of the circuitry design and manufacturing operations in the company's High Power Microwave Tube Division.

A graduate of the University of Idaho, Haegele received his masters degree in business administration from Stanford University.

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TERRY ERECTS EXPERIMENTAL ANTENNA TOWER

An augmented program of microwave development and production for Terry Microwave Electronics & Construction, Inc., Long Island City, N. Y., has been announced by Dr. Judd Blass, president.

The announcement coincides with the construction of an experimental tower, 65 feet above street level on the roof of 11-11 Thirty-fourth Ave., the headquarters of Terry Industries, of which Terry Microwave is an affiliate.

Plans for the steel tower have been approved by the Queens office of the city's Department of Buildings. The only such tower in the area, the structure is to be part of a 2000-foot antenna test range. It will hold radar scanners and experimental antennae of the most advanced types.

Dr. Blass said the tower is to be one of the principal tools in the development and production of antennae, with particular emphasis on electronically scanned arrays and radar systems for high-data rates of information.

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VARIAN KLYSTRONS INVOLVED IN WORLD COMMUNICATIONS PROJECT

Two high-power microwave tubes built by Varian Associates, Palo Alto, Cal., are at the heart of America's latest experiment in global communications — Project West Ford.

The project involves millions of tiny dipoles placed in a belt-like orbit around the earth. Microwaves for communications can be beamed at this band and reflected to receiving stations thousands of miles away.

Varian klystrons in transmitters on both east and west coasts will provide the tremendous microwave power needed to get messages up to the dipole belt and back down again.

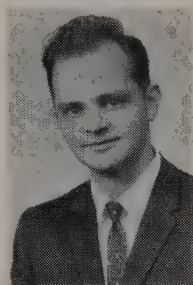
Rocketed into orbit from Point Arguello, California, aboard an Atlas-Agena rocket, the 75-pounds of metallic dipoles are expected to take about a month to spread into an even belt suitable for test transmission of messages from coast to coast. Scientists hope the belt will provide an answer to a growing need for reliable communications over very long distances with a large message-carrying capacity (bandwidth).

A Varian VA-849 klystron (giving 20,000 watts of continuous wave power at 8-billion cycles per second) is mounted in the west coast transmitter. Another Varian tube, the VA-823 (giving 5000 watts at the same frequency), is part of a Varian-built transmitter modified for this job by Lincoln Laboratories and located on the east coast.

— m w j —

DOWDELL APPOINTED MANAGER-INSTRUMENTS BY MSI ELECTRONICS

Mr. Edward F. Dowdell has joined MSI Electronics, Inc., a wholly-owned subsidiary of Microwave Semiconductor & Instruments Inc., Richmond Hill, N. Y., as Manager-Instruments, Albert Lederman, president of MSI has announced.



DOWDELL

Mr. Dowdell will be responsible for the development and manufacture of commercial and military microwave instruments and power supplies of unusual stability for use with klystrons, traveling wave tubes and backward wave oscillators. Prior to joining MSI, Mr. Dowdell had been project engineer with Microwave Dynamics Corp. and had worked on microwave power supplies and test equipment with a number of well-known electronics firms since 1952.

Mr. Dowdell will report to and work closely with Mr. Sidney Appleman, chief engineer of MSI.

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(Continued on page 60)

Inquire about Sperry Tubes from these convenient Cain & Company offices

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San Francisco, California
Phone YO 8-0995

San Diego, California
Phone HU 8-0665

Seattle, Washington
Phone MA 3-3303



Sperry adds high-power pulsed TWT's to list of tubes available in 30 days

In a move to simplify design problems of present and future radar systems, Sperry Electronic Tube Division of Sperry Rand Corporation has added two high-power pulsed traveling wave tubes to the list of advanced microwave tubes available in 30 days.

The two tubes covered by the announcement—the STL-114 and the TC-152—operate in L and C bands, respectively. They are typical of a line of pulsed TWT's ranging from through V bands which Sperry offers on a firm delivery date basis.

EASY RADAR APPLICATION

Sperry's pulsed TWT's are admirably suited to the demands of application in phased array radars, height finders, search, ECM, and other radar applications. Widely varied in-system experience has proved that their reliability, long life, high power, high gain, and extreme broadband operation make them ideal for radar use.

Design features of this tube family minimize the necessity for system adjustments in the field. Among these features are broadband response, constant voltage operation, and short circuit stability.

VERIFIED RELIABILITY

These pulsed TWT's, produced at Sperry's Great Neck, N. Y., facility, have compiled an impressive record of in-system experience. Such experience has proved that their resistance to shock and vibration damage, their inherent indifference to ambient conditions, and their mounting flexibility make them ideal for ground or airborne application.

Place your order with your Cain & Company representative. His phone number appears in the adjacent column. Tubes are available within 30 days after receipt of order.

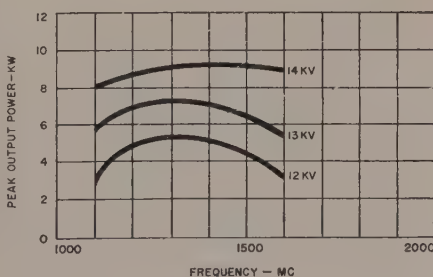
FREE TECHNICAL INFORMATION on the Sperry line of high-power pulsed traveling wave tubes may be obtained by writing to Sec. 105, Sperry Electronic Tube Division, Gainesville, Florida.

V BAND CAPABILITY

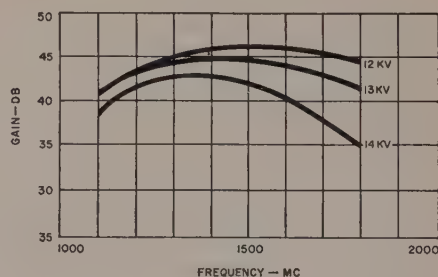
Among Sperry's other interesting activities in pulsed TWT's is the extension of capability into the V Band—26.5 to 40.0 kMc. Although these efforts are largely classified, inquiries are invited from those who have the necessary clearance and need to know.



FACTORY ALIGNMENT of a Sperry TWT within its focusing solenoid greatly simplifies field maintenance. Once this operation has been performed by a skilled Sperry technician, the assembly is self-aligning.



Typical saturated power output vs. frequency for a pulsed Sperry TWT.

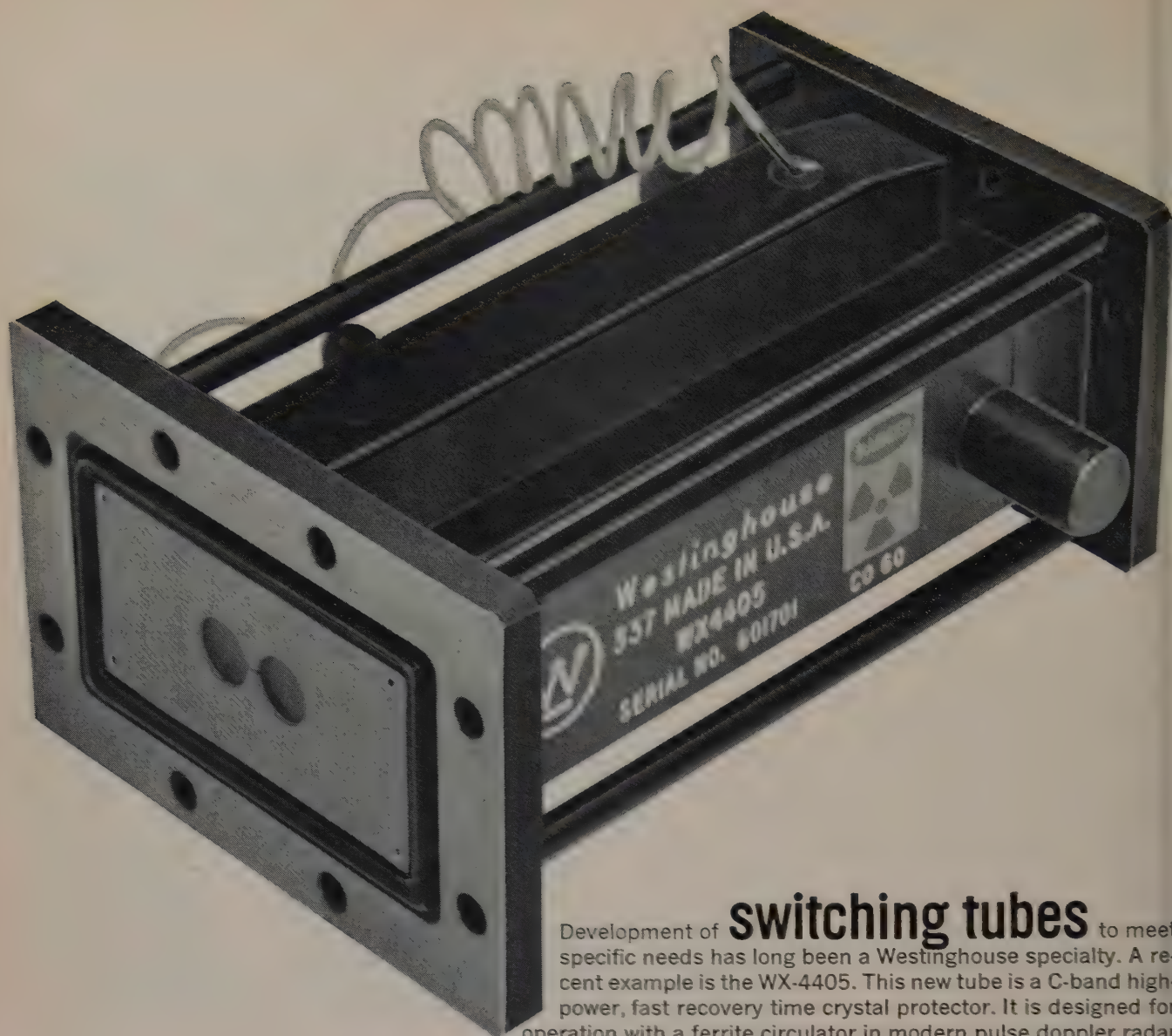


Typical small signal gain vs. frequency for a pulsed Sperry TWT.



**ELECTRONIC
TUBE
DIVISION**

GAINESVILLE, FLA. / GREAT NECK, N. Y.
SPERRY RAND CORPORATION



Development of **switching tubes** to meet specific needs has long been a Westinghouse specialty. A recent example is the WX-4405. This new tube is a C-band high-power, fast recovery time crystal protector. It is designed for operation with a ferrite circulator in modern pulse doppler radar systems . . . and features a recovery time of 0.1 to 0.2 microseconds. ■ In a life test WX-4405 has operated over 1800 hours at full ratings with a recovery time of 0.15 microseconds, maintaining its original value. ■ For information on your application—standard or special—write on your company letterhead to: Westinghouse Electric Corp., Elmira, N. Y. You can be sure . . . if it's Westinghouse.

Characteristics of WX-4405

Waveguide Size	Input 2" x 1" Output 1.5" x .75"	*Recovery Time	0.2 u sec. max.
Frequency	5250-5650 Mc	Insertion loss	0.6 db max.
Peak Power	1 KW	Application	Pulse Doppler Radar
Duty	0.1	Advantages	Combination Pre-TR and crystal protector in one envelope
Special Characteristics	Fast recovery time at high power		

Versions of this tube can be supplied which operate at 3 Watts and at 50 Watts peak power with lower insertion loss, also scaled versions at other frequencies. *Recovery time is usually measured from the time that the transmitter power has dropped to 10% of its full value, to the time the insertion loss has recovered to within 3db. of its fully recovered value.



Westinghouse

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the microwave journal

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Industry News

(Continued from page 54)

WARRINER APPOINTED PRODUCT PROGRAMS MANAGER AT RAYTHEON

Ben Warriner has been named manager, product programs for Raytheon Company's Microwave and Power Tube Division, Waltham, Mass.



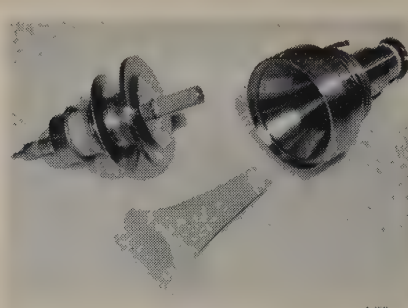
WARRINER

Warriner joined Raytheon in January of this year. Earlier he had been with Collins Radio Co. as manager of its research and development division and as its government representative at Hanscom Air Force Base, Bedford, Mass.

A Johns Hopkins University graduate, Warriner holds a masters degree from Virginia Polytechnic Institute. He is a member of the IRE and the U. S. Naval Institute. He founded the IRE's professional group on microwave theory and techniques and served as its chairman from 1952 to 1954. Since then, he has been active in various IRE committee activities.

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HIGH PERVEANCE GUN EXTENDS HOLLOW BEAM TUBE CAPABILITIES



A high perveance gun, developed by Raytheon Company's Spencer Laboratory, Burlington, Mass., greatly extends hollow beam microwave tube capabilities.

So-called because its cathode is nearly identical with that used in magnetrons, the magnetron injection gun has low voltage operation, lower x-ray level, enhanced bandwidth, longer life.

Accelerating electrodes and a magnetic field in the gun are so shaped that electrons are injected from it in the shape of a hollow cylinder which enters the interaction region of the tube.

A conventional klystron, operating at ten megawatts, would require a beam voltage of about 235 kilovolts. Raytheon's new high perveance gun permits the same power level with only 115 kilovolts. Equipment requirements are thereby relaxed and cost savings are upped.

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ELSNER CHOSEN ENGINEERING MANAGER AT MOTOROLA

Ralph W. Elsner has been appointed engineering manager of Western Center, Motorola Military Electronics Division, Scottsdale, Ariz., it was announced by Dr. Robert E. Samuelson, assistant general manager for Research and Development.



ELSNER

In his new position, Mr. Elsner will plan and direct the business and technical efforts of both the Radar Systems Laboratory and the Communications Navigation and Data Processing Laboratory. Current activities include design and development of electronic equipment in the fields of communications, navigation, guidance, control and tracking of aircraft, drones, missiles, space probes and satellites, as well as vehicular communication and airborne surveillance.

Mr. Elsner was formerly manager of the Radar Systems Laboratory. He has been with Motorola for the past twelve years as project leader, section head, assistant chief engineer, and laboratory manager.

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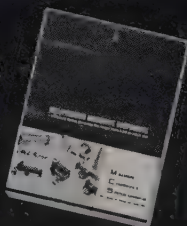
(Continued on page 62)

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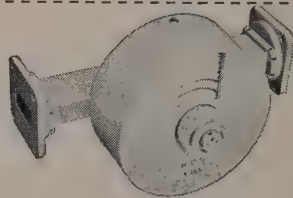


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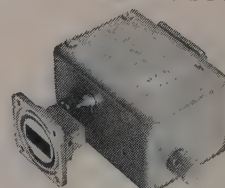
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ULTRASTABLE MICROWAVE SIGNALS...

their generation and the measuring
and analyzing of their perturbations



by PETER P. JORRENS
Engineer, Instrument Division
LABORATORY FOR ELECTRONICS, INC.



at frequencies over 2 Gc/s, the generation of extremely stable microwave signals is a substantial problem. And even more vexing is the problem of determining just how stable a signal is, once a very stable signal has been achieved. Such problems have become important since microwave signal sources are now needed in many diverse fields wherein stability to a few cycles per second is necessary and desirable.

For all critical applications, two kinds of instability are of primary concern: residual frequency modulation, periodic or non-periodic, as well as its cause, which we call short-term instability; and drift, which is long-term instability.

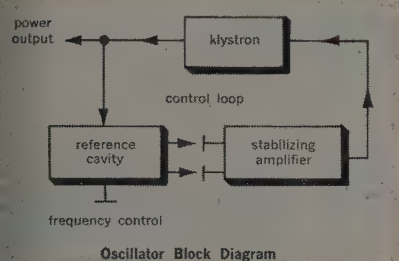


Figure 1

The best commercially available signal generators have these specifications: residual frequency modulation of approximately five parts in 10^8 or better; drift, one part in 10^6 per hour under ordinary environmental conditions. As shown in Figure 1, a reflex klystron is employed as the generator, part of whose output is fed to a dual-mode invar reference cavity acting as a frequency discriminator. After rectification, any error signal is greatly amplified and employed to keep the klystron closely locked to the mean frequency of the dual-mode cavity.

However, this is not all. Rugged mechanical design, dc on all critical electron tube heaters, broadband crystal mounts with high sensitivity, and electronically regulated power supplies as well as years of production experiences are required to permanently

subdue some nasty problems and to meet the specifications mentioned.

The only commercially available instrument capable of checking ultrastable oscillators to such specifications is arranged as shown in Figure 2, and employs a unique quantizing circuit to detect f-m modulation and frequency drift. Up to the point of detection, the circuit is basically that of a double superheterodyne receiver of extraordinary stability and refinement. There is one difference however: because of extreme limiting in the 2nd i-f amplifier, a sinusoidal input signal is converted to very steep-edged square waves. These are differentiated, and the positive-going spikes are used to trigger a multivibrator which, by means of a delay line, generates one constant-energy pulse for each cycle of input to the 2nd i-f amplifier. Each pulse has a constant amplitude E and constant width t .

The average output voltage is $E_o = E t f$ where f , the 2nd i-f frequency, is the only variable. By using a d-c, zero-center voltmeter, with graduations in kc/s, plus or minus frequency drift can be measured around the initial frequency of the oscillator under test.

If frequency modulation exists, there is an a-c component superposed on the average d-c level whose magnitude is $dE_o = E t df$. To recover this component for display, the quantized pulse train is filtered to remove the 120 kc/s carrier and frequencies over 20 kc/s, amplified, rectified, and applied to a meter calibrated to read peak frequency deviation.

This particular instrument, with a bandpass from 15 cp/s to 20 kc/s, has drift scales

of ± 5 and ± 50 kc/s, eight peak deviation ranges from 10 to 30,000 cps. Minimum measurable f-m deviation varies from 0.3 cps at L-band to 2 cps at Ku band.

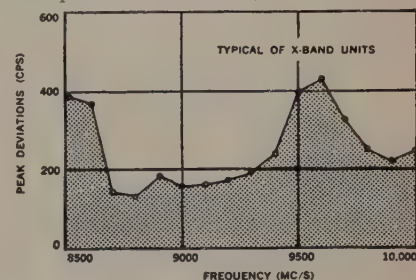


Figure 3

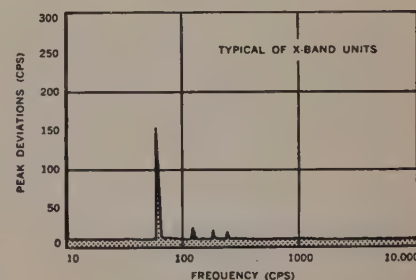


Figure 4

LFE makes both of these instruments: the 814 Series of Ultrastable Oscillators and the Model 5024 Stability Tester. Figures 3 and 4 illustrate typical X-band peak deviation versus output and disturbance frequencies respectively, and figure 5 shows both a Model 814 oscillator and a Model 5024 stability tester. The small instrument, also shown and available, is a Model 240

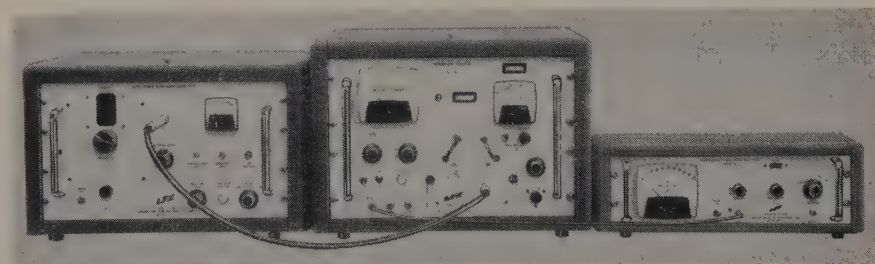


Figure 5

tunable filter for spectrum analysis of disturbance frequencies.

An interested reader can obtain much more detailed information by requesting Bulletins 814 and 5024. For these bulletins, or the answers to particular questions, write Mr. Perry Pollins at the address below.

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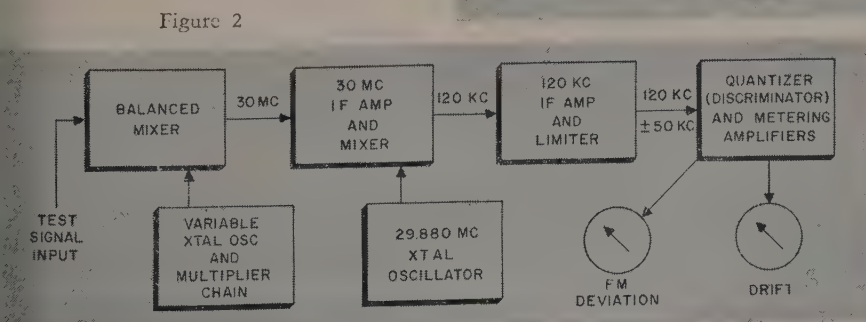


Figure 2

Circle Reader Service Card 42

(Continued from page 60)

SIGURD VARIAN

Sigurd Varian, 60, a founder of Varian Associates, Palo Alto, Cal., and an electronics pioneer, was killed recently in an airplane crash in a heavy sea off the west coast of Mexico. Mr. Varian was instrumental, with his brother, Russell, in developing the klystron tube that made relay radar possible.

A pioneer Pan American Airways pilot in Mexico, Mr. Varian as early as 1935 recognized the need for some method of preventing airplane crashes in fog, darkness or bad weather. When Russell, then a graduate student in physics at Stanford University, conceived the idea of using short wave radio beams for this purpose, Sigurd left his job and devoted his full energies, along with his life savings, into developing a practical device that would prove Russell's theory. Using the research facilities at Stanford, the Varian brothers spent three years on the project which resulted in the klystron, a microwave device that made possible World War II radar.

After spending the war years working on secret government radar projects, the Varian brothers returned to California in 1948 to form Varian Associates. In 1950,

Sigurd and Russell Varian were awarded the John Price Wetherill Medal of the Franklin Institute of Philadelphia "in recognition of their foresight in anticipating the need for a converter of electromagnetic energy in a hitherto unexplored high frequency region of the spectrum, their energy and technical insight in developing for this purpose a practical device, the klystron, which has opened up new fields in communications applications and research."

Holder of numerous patents for inventions in microwave and other fields, Sigurd Varian was active in engineering and development work at Varian Associates until a few years ago. He retired to Puerto Vallarta, returning frequently to California for business reasons and to visit friends and family.

Despite his retirement, Sigurd retained his keen interest in trying out new ideas. He continued inventing new devices of all kinds—from a precision high speed drill to a system of pumps, filters and heaters for his swimming pool.

WEISS NAMED RESEARCH LABORATORY DIRECTOR AT AEROSPACE

Dr. Max T. Weiss has been named rector of the Electronics Research Labo-



WEISS

tory at Aerospace Corp., El Segundo, Cal. Dr. Chalmers W. Sherwin, vice president and general manager of Laboratories Division, has announced.

The laboratory is responsible for advanced research in the fields of solid state electron-

quantum state electronics and electromagnetics and communications techniques.

Dr. Weiss had been assistant director of the Applied Physics Department of Hughes Aircraft Company. His fields of work have included ferromagnetic resonance, spectroscopy and optical masers.

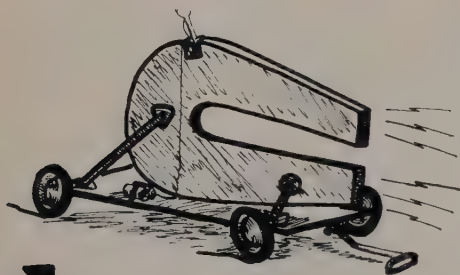
Dr. Weiss earned his M.S. and Ph.D. degrees in physics at the Massachusetts Institute of Technology, and his B.S. degree in electrical engineering at the College of New York.

He is a member of the IRE, the American Physical Society, Sigma Xi, an honorary science fraternity, and Eta Kappa Phi, an honorary electrical engineering fraternity.

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(Continued on page 68)

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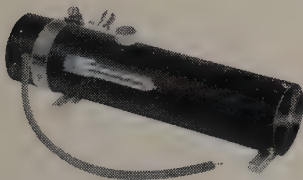
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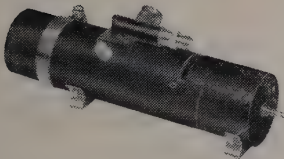
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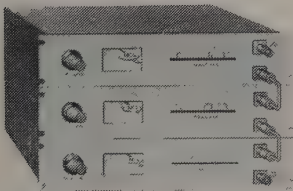
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This new B.F. Goodrich booklet describes by types and physical characteristics BFG's line of broadband and resonant type absorbers. Tells how to use these materials to simulate free space conditions, to eliminate radar-distorting reflections, and to create year-round all-weather test facilities. Send request on your company letterhead. B.F. Goodrich Sponge Products, 130 Derby Place, Shelton, Connecticut. Foreign inquiry, except from Canada, should be addressed to Microwave International Corporation, 36 West 44th Street, New York 36, New York.

MICROWAVE ABSORBERS BY



THE NEW PGMTT CONSTITUTION

By ROBERT D. WENGENROTH

An amended Constitution has been prepared for the Professional Group on Microwave Theory and Techniques of the Institute of Radio Engineers. The amendments bring the Constitution into accord with current IRE practice, and have been approved by the Administrative Committee of the PGMTT, by the IRE Professional Groups Committee, and by the IRE Executive Committee. Balloting on the amendments by the members of the Group ends on January 31, 1962.

The Professional Group in Microwave Theory and Techniques is a specialists' Group in the IRE. It publishes the *IRE Transactions on Microwave Theory and Techniques*, holds an Annual Conference, and supports other programs which aid the flow of technical information in its field of interest. The new statement of the PGMTT field of interest includes: "—Microwave Theory, Techniques and Applications; Microwave Components, Devices and Circuits; the Generation, Amplification, Transmission and Detection of Microwaves—"

Membership in the PGMTT is open to all IRE members, and Affiliate Membership is open to members of the American Physical Society or the Institution of Electrical Engineers of Great Britain.

The Professional Group Constitution is the basic set of rules for operating the Group as a nearly autonomous part of the Institute of Radio Engineers. The Constitution outlines the privileges of the Group as a part of IRE, details the responsibilities of the Group to the IRE, and sets forth the obligations of the Group Administrative Committee in operating the Group for its membership. Therefore, the Constitution or any amendment to it requires three approvals. First is the approval of the IRE Professional Groups Committee, which is charged with coordinating Professional Group activities. Second is the approval of the IRE Executive Committee, which is responsible to the IRE Board of Directors, and through them to the IRE membership for all IRE activities. Third is the approval of the Professional Group membership for whose benefit the Group is operated. The amended Constitution for the PGMTT has the first two approvals; its acceptability to the membership is being determined through the balloting.

Many changes have been incorporated into the proposed new PGMTT Constitution. A few are major, but most are technicalities. Major changes appear in the articles on Field of Interest, Amendments, and Publications.

The statement of the Group's field of interest has been changed to more accurately reflect the wide coverage of

the Group. Discussion at meetings of the PGMTT Administrative Committee indicated that "Microwaves" refers not to a narrow portion of the electromagnetic spectrum but is a term applying at all frequencies when the theory, technique or practice is that of a device comparable to a wavelength where lumped parameters can not be assumed, and where simple optical theory is also not sufficient.

The procedure for amending the Constitution is being changed. The new procedure permits an amendment to become effective if, within thirty days of publication in the *Newsletter* which is received by all members, objections are raised by less than ten per cent of the members. If ten per cent or more object, a ballot on the amendment must be taken. The voting, when required, is conducted in the same manner as provided in the old Constitution. The amendment must be approved by a majority of those submitting ballots, and twenty per cent of the membership must vote within not less than 30 days of the mailing of the ballot for the balloting to be valid. The reason for the change is to reduce the cost and effort required to get approval of an amendment. Amendments normally are carried by a large majority, but getting a twenty per cent return is difficult. The new procedure permits the least number who could have blocked an amendment before to force a ballot now. The new procedure is intended to preserve full membership control of amendments while reducing the usual cost of the procedure.

The Article on Publications has been rewritten to specify that the Group shall publish at least four issues of the *Transactions on Microwave Theory and Techniques* each year. No publication was required under the old Constitution. There are no plans to change from the current rate of six issues a year.

Information on the remaining amendments is available in the PGMTT *Newsletter*, which is mailed to all members of the Group. Most are changes in wording; a few are clarifications of Group procedures. The important changes were discussed above.

The PGMTT Administrative Committee hopes that a large fraction of the Group members will consider the amendments carefully and submit their ballots. If you are a PGMTT member and did not vote, you are urged to submit your ballot, which was the last page of the December 1961 *Newsletter*, or you may send a separate letter ballot indicating your vote for or against the amendments, stating, "I certify that I am a member of the IRE Professional Group on Microwave Theory and Techniques," and signing the ballot.

If you are not a member of PGMTT, why not join?

ROBERT D. WENGENROTH is Chairman of the Constitution and Bylaws Committee of the IRE Professional Group on Microwave Theory and Techniques. He has been a member of the PGMTT Administrative Committee since 1958, and earlier was Secretary-Treasurer and Newsletter Editor. He was organizer, Vice-Chairman, and Chairman of the Long Island Chapter of PGMTT.



Mr. Wengenroth has been an engineer with the Heavy Military Electronics Department of the General Electric Company in Syracuse since 1960. He is a licensed Professional Engineer of the State of New York, a member of IRE, Tau Beta Pi, and Eta Kappa Nu, and an associate member of AIEE and Sigma Xi.

Nomogram on the Half Power Beamwidth of a Continuous Array

B. R. HATCHER

CHU ASSOCIATES

Littleton

Massachusetts

The nomogram relates the half power beamwidth $\theta_{1/2}$, of a continuous array, to the aperture size in wavelengths

$\frac{a}{\lambda}$, and the aperture distribution function $f(x)$ for three common distribution functions and a number of parameters.

The distribution functions are:

1. The gabled taper $f(x) = 1 - \left| \frac{x}{a} \right|$
2. The cosine taper $f(x) = \cos^n \frac{\pi x}{a}$ in which n is a parameter
3. The parabolic taper $f(x) = 1 - p \left(\frac{2x}{a} \right)^2$ in which p is a parameter

The variable x is measured from the center of the array. The cosine and the parabolic distributions reduce to the uniform array for $n=0$ and $p=0$ respectively. The illumination is zero at $x = \pm \frac{a}{2}$ for the gabled and cosine

(all n) distributions and for the parabolic distribution

for $p=1$. The parabolic excitation has a pedestal for $p < 1$, and is not efficient for $p > 1$.

In the nomogram, the figures in parenthesis beside the parameter represent the theoretical first sidelobe level in decibels for an array having that parameter.

For a specified distribution function, the nomogram may be used to determine either the half power beamwidth when the array length is known, or the length required to produce a specified beamwidth. To use the nomogram, connect two known values with a straight line. The third is given at the intersection of the line and the appropriate scale.

For example, assume a $\cos^2 \left(\frac{\pi x}{a} \right)$ distribution. A

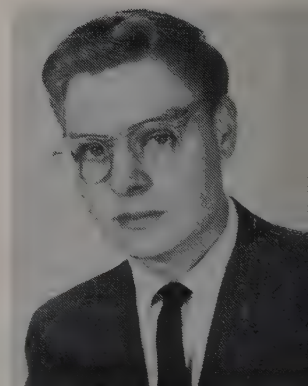
array 5λ long produces a beam having a half power beamwidth of 16.6° .

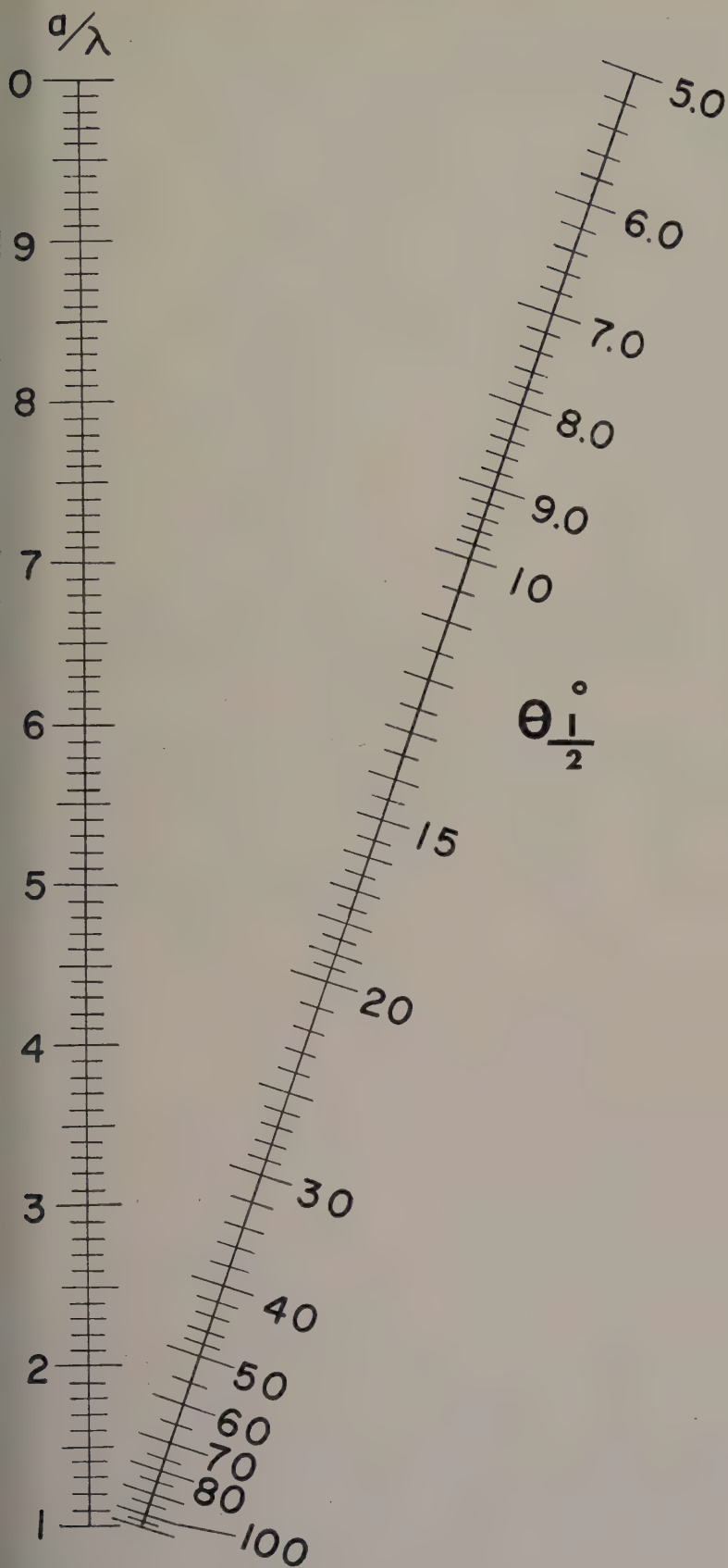
The range of the nomogram may be extended by multiplying the $\frac{a}{\lambda}$ scale by 10^k and the $\theta_{1/2}$ scale by 10^{-k} .

Thus, using the parameters of the example above, a array 50λ long produces a half power beamwidth 1.66° . In both cases the theoretical sidelobe level is 32 db.

BURRELL R. HATCHER was born December 25, 1937 in El Paso, Texas. He graduated from M.I.T. in June 1959 with a BS degree in electrical engineering. He is presently working for a Masters degree in electrical engineering at Northeastern University.

Mr. Hatcher was employed from June to September, 1955 through 1958 by Convair, San Diego Division, in the Ground Support Equipment and Antenna Research groups. He is presently employed as a project engineer at Chu Associates, Littleton, Mass.

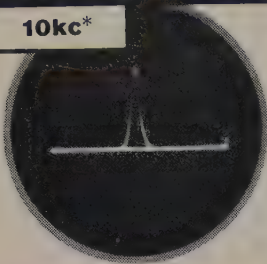




p	n
0(13.2)	0(13.2)
.2(15.8)	
.5(17.1)	
1.0(20.6)	
	1(23.0)
GABLED	(26.4)
	2(32.0)
	3(40.0)
	4(48.0)

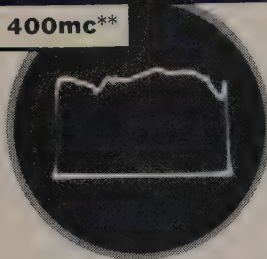
VERY NARROW

10kc*

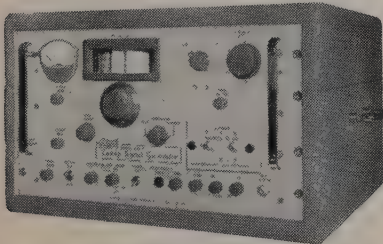


TO VERY WIDE

400mc**



SWEEP WIDTHS
...all in one instrument



NEW **JERROLD**® 900B SWEEP SIGNAL GENERATOR

The new Jerrold 900B is the last word in versatility and precision, the ultimate instrument for all your IF, VHF, and UHF sweep requirements. Bench space requirements and test set-up time are drastically cut because so much is already built in:

- Built-in crystal-controlled harmonic markers at 1, 10, and 100mc intervals.
- Built-in variable-gain dc or ac-coupled 'scope preamplifier with 200X maximum gain.
- Built-in precision attenuator from zero to 50db in 10db steps.

Generating sweeps with center frequencies ranging from 500kc to 1200mc, the 900B offers unusual stability with sweep widths as narrow as 10kc and as wide as 400mc. Write for complete technical data.

\$1,980.00 f.o.b. Philadelphia

*Typical communication receiver IF (selectivity approx. 6 kc).

**Frequency response of typical wide-band distributed amplifier (4-216 mc).

JERROLD® **ELECTRONICS CORPORATION**
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Jerrold Electronics (Canada) Ltd., Toronto
Export Representative: Rocke International, N.Y. 16, N.Y.

Industry News

(Continued from page 62)

KENT NAMED PRESIDENT OF CONSOLIDATED MICROWAVE CORP.

Henry T. Starkand, president of Decitron Electronics Corp. of Brooklyn, N. Y., announces the formation of its new affiliate, Consolidated Microwave Corp. in Brooklyn. CMC is headed by Leonard I. Kent who will be president. Mr. Kent is vice president and director of engineering of Decitron.



KENT

CMC will participate in the design, production, research and development of specialized microwave equipment and instrumentation which will include solid state and ferrite devices.

Among Mr. Kent's accomplishments have been contributions in the field of directional couplers, ridged waveguides, millimeterwave techniques, bolometric and solid state devices. Several papers have been written by him on these subjects.

Mr. Kent is a graduate of the Cooper Union School of Engineering, where he received a B.E.E. He has also been awarded an M.E.E. and is completing requirements for the D.E.E. at the Polytechnic Institute of Brooklyn. He is a senior member of the IRE and the IRE Professional Group on Microwave Theory and Techniques.

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JERROLD ENTERS RADAR FIELD

Jerrold Electronics Corp., Philadelphia, Pa., has announced that its Philadelphia operation which recently entered the area of microwave equipment sales now has extended its electronic construction facilities to installations in the radar field.

Max Kraus, manager of Jerrold's Communication Systems Division, announced the completion of cable installations, ground wiring and electrical connections for the highly advanced AN/FPS-24 radar system at an air station in California. The radar system, for detection of supersonic aircraft and "air-breathing" missiles, was designed and installed by the Heavy Military Electronics Department of General Electric, prime contractor. The installation is one of a number of this type of radar installation at air stations throughout the country. Jerrold will perform similar work at other sites.

Jerrold's entry into the field of radar systems installations, according to Mr. Kraus, marks a major expansion of the Division and its capabilities for offering additional construction facilities for military installations.

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SIX POSITIONS FILLED AT MICROLAB

The promotion of four management personnel and the creation of two new positions has been announced by Harry A. Augenstein, President of Microlab, a Livingston, New Jersey microwave component manufacturer.

Named in divisional posts were John C. Vogler, Engineering Division Manager; Harry C. Dolan, Marketing Division Manager; Albert Sachs, Vice President and Manufacturing Division Manager; Eugene R. May, Administration Division Manager. The newly created position of Planning Director will be filled by Vice President, Richard C. Hess and the Technical Director post by Herbert F. Engelmann, also a Vice President.

The planning and technical offices under the direction of Mr. Hess and Mr. Engelmann will be responsible for the determination of Microlab's intermediate and long term requirements including the investigation of new areas of interest and fields of endeavor; technical guidance for product development and new areas of technical achievement.

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AIR FORCE CONTRACT AWARDED TO SYLVANIA

Receipt of an Air Force contract extension award which ultimately will total approximately \$7 million was announced today by General Telephone & Electronics Corporation.

The award was made to the Mountain View Operations of Sylvania Electronic Products Inc. for engineering and production of receiving equipment. Since its inception in 1959, the project has brought Sylvania approximately \$18 million in contract awards.

The project is conducted within the Reconnaissance Systems Laboratory of the Mountain View Operations. Harold Graves will continue to head up the Mountain View portion of the program according to Jesse R. Lien, General Manager of the Mountain View Operations.

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DOWNEY NAMED MARKETING ADMINISTRATOR

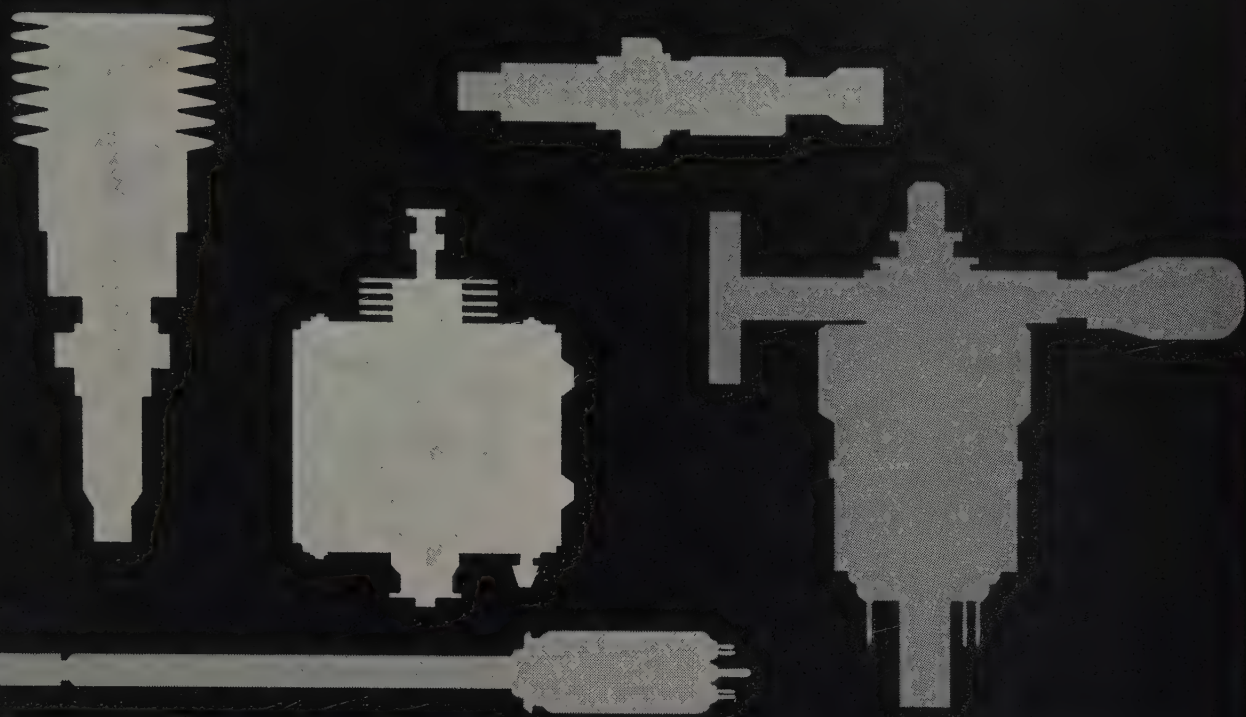
The appointment of Frank A. Downey as a marketing administrator has been announced by Manson Laboratories, Inc., Stamford, Conn.

Manson designs and builds specialized electronic equipment including precise oscillators; frequency standards; UHF, HF and single sideband communications equipment; and high powered modulators, power supplies, transmitters and test equipment.

Prior to joining Manson Laboratories Inc., Mr. Downey was assistant sales manager for the Carmody Corp. He has also been associated with Electronic Controls Inc., as a sales representative, and with the Southern New England Telephone Company in a similar capacity.

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UNITED BY RELIABILITY



RELIABILITY BY UNITED

**NEW ADVANCED LINE OF MICROWAVE TUBES NOW AVAILABLE
... TRIODES, KLYSTRONS, WAVE TUBES, OSCILLATORS**

Disc-Seal Triodes	Typical Operation					Maximum Ratings			Heating	
	f kMc	f kMc	P _o W	E _b V	I _b V	E _b V	P _p W	I _k mA	E _f V	I _f A
RH 6 C	up to 7	4	4	400	60	600	30	72	6.0	0.9
RH 7 C	up to 9	6	1.8	400	60	600	25	72	6.0	0.9

Reflex Klystrons	Typical Operation								Heating	
	f kMc	P _o W	Δf Mc	S _m Mc/V	ΔS _m /S _m %	E _b V	I _b mA	focus. * electr.	E _f V	I _f A
RK 6	5.775 ... 5.925	0.10	60	2.5	1	400	50	1.	6.3	1.2

Traveling Wave Tubes	f kMc	P _o W	G db	F db	E _c V	E _h V	I _c mA	focus. * electr.	E _f V	I _f A
RW 6	5.8 ... 6.8	10	38	25	1250	2500	44	2	6.3	1

Backward Wave Oscillator	f kMc	P _o mW	E _{cd} V	I _{cd} mA		focus. * electr.		E _f V	I _f A
RWO 40	30 ... 45	40	800 ... 2700	12		4		6.3	1

* Focusing electrodes

WRITE FOR COMPLETE TECHNICAL INFORMATION

**UNITED
ELECTRONICS
COMPANY**

A SUBSIDIARY OF

LTV

LING-TEMCO-VOUGHT, INC.

42 SPRING STREET • NEWARK 4, NEW JERSEY

AMPHENOL-BORG REVEALS THREE MONTH CONSOLIDATED EARNINGS

Consolidated earnings of Amphenol-Borg Electronics Corp., Broadview, Ill., and its subsidiaries for the three months ending Sept. 30, 1961, were \$428,663, or 31¢ a share, compared to \$593,756 or 43¢ per share, for the comparable period in 1960. Sales for the 1961 period were \$18,512,742 compared to \$15,943,825 for the comparable period in 1960.

Consolidated net income for the nine months ended September 30, 1961, was \$892,133, or 64¢ per share, compared with earnings of \$2,126,704, or \$1.53 a share for the comparable period in 1960. Sales for the 1961 period were \$53,153,796 compared with \$51,169,830 for the 1960 period, an increase of 4 per cent.

"Operations in the third quarter were adversely affected by losses in the FXR and Packaged Electronics Divisions and start-up costs in our West German subsidiary," said Matthew L. Devine, president. He further stated that FXR should be operating on a profitable basis by the end of the year. "Orders and shipments for connector operations continue to improve, reflecting the results of the reorganization made in 1960, and it is expected that the Company will show continued improvement in the future," he added.

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EARNINGS OF RAYTHEON CONTINUE TO INCREASE

Earnings and earnings-to-sales ratio continued upward for the second consecutive quarter, a third quarter statement, from Raytheon Co., Lexington, Mass., showed recently.

Earnings in the third quarter totaled \$1,838,000 after taxes, or 45 cents per common share on 3,890,578 shares outstanding. Sales totaled \$126,962,000. Earnings per share reflect provision for payment of preferred dividends. "Third quarter earnings were 1.4% on sales, versus a 1.2% return in the second quarter and a 1.0% return in the first quarter," Richard E. Krafve, company president, reported.

In the like period last year, earnings were \$1,952,000, or 50 cents per share on 3,725,414 common shares then outstanding. Sales were \$125,266,000.

Earnings in the first quarter of 1961 were \$1,365,000, or 33 cents per share on sales of \$138,158,000. Shares outstanding at that time were 3,855,045. Earnings in the second quarter were \$1,644,000, or 40 cents per share on sales of \$142,022,000. Shares outstanding were 3,888,764.

Total sales for the first nine months of 1961 were \$407,142,000, with earnings of \$4,847,000, or \$1.18 per common share. By comparison, sales at the end of nine months in 1960 totaled \$402,830,000, and profits from operations of \$6,139,000, or \$1.58 per share.

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SANDERS PRESIDENT EXPECTS SALES JUMP TO OVER \$40 MILLION

President Royden C. Sanders, Jr., recently told the annual meeting of stockholders of Sanders Associates, Inc., Nashua, N. H., that he expected sales would jump from the \$21.1 million reached in fiscal 1961 to over \$40 million for fiscal 1962, and then go over \$50 million in fiscal 1963.

"Current operating rate in terms of annual production is approximately \$40 million, which is ground for confidence that the over \$40 million sales figure can be reached," he said. "The company's backlog which has gone over the \$100 million mark, strongly supports the sales forecast of over \$50 million for 1963."

The company has sufficient financing for expansion of production to sales of \$50 million. Daniel C. Chisohlm, treasurer, said that he hopes additional expansion can be financed out of earnings, but does not entirely rule out the possibility of new financing at a later date. He also said that the advantages of listing on one of the major stock exchanges has been studied but no conclusions for action have been reached.

George Rowen, vice president for manufacturing, was elected as a new member of the Board of Directors. He has served in his present post at Sanders for almost two years. He was previously corporate vice president of Sparton Corporation.

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Letter to the Editor

Editor
the microwave journal

The short article "Determination of Maximum Insertion Loss Error Due to Mismatch," Herman J. Feist, Microwave Journal, 4 No. 10, 96-97, October 1961, is more than vaguely familiar. It covers the same material that appeared in "Cascade Connected Attenuators," R. W. Beatty, Proceedings of the IRE 38, No. 10, 1190, October 1950, and Journal of Research of the National Bureau of Standards, 45, No. 3, 231-235, September 1950.

This letter is to point out that a method for the evaluation of overall errors when connecting a number of known attenuators in cascade was investigated and published by the National Bureau of Standards as indicated above. As far as I know, this NBS work has not been superseded by a more effective method and the units, terminology and language are still the same.

In our current technical literature we look for the new although some items may be referred to and rewritten and republished for educational purposes. In the subject instance I suspect we have another example of work undertaken and published without a thorough look at the past.

Very truly yours,
R. W. Beatty, Chief
Microwave Circuit Standards
Radio Standards Laboratory

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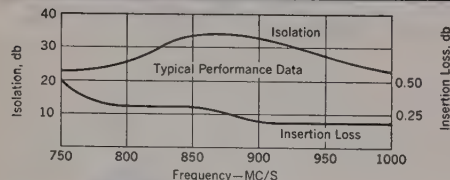
the microwave journal

New Micromega Circulator & Isolator Is Tunable 750-1000 MC!

Now available from Micromega is the first UHF Circulator or Isolator* that can be mechanically tuned from 750MC to 1000MC. A calibrated dial permits tuning within seconds.

SPECIFICATIONS: Frequency (tunable), 750 to 1000MC; Min. Isolation, 20.0 db; Max. Insertion Loss, 0.6 db; Bandwidth, 10%; Max. VSWR, 1.25; Connectors, Type N.

*A built-in load converts the circulator into an isolator.

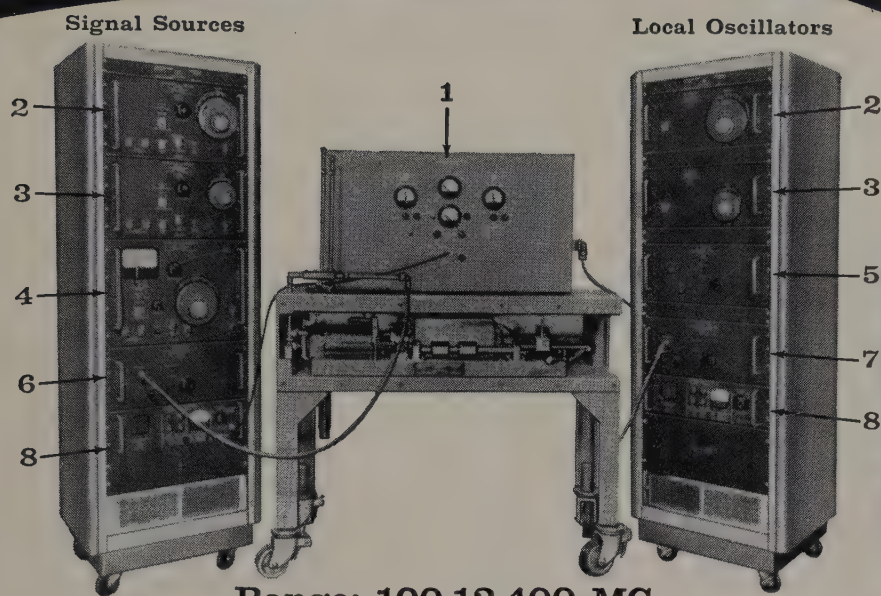


Model NL251T Circulator

MICROMEGA CORPORATION
4134 Del Rey Ave., Venice, Calif., EXmont 1-7137



Complete Attenuation Measuring System VM-1 by WEINSCHEL



Range: 100-12,400 MC

Picture shows a complete system for the range 100-4000 MC.
Signal sources and local oscillators to 12,400 MC available.

Makes a 70 DB measurement with 0.02 DB precision

This is the only complete working system commercially available from one source which offers standards laboratory accuracy over such a great dynamic range. Each component is designed for compatibility, resulting in optimum systems performance. This Weinschel system does perform:

A 60 db measurement with an accuracy greater than 0.12 db starting with 20 millivolts (-21 dbm)

A 120 db measurement with accuracy greater than 0.4 db starting with 2 volts ($+19$ dbm)

Saves Time of Skilled Personnel

The VM-1 is **direct reading**, easy to use. No calibration curves or correction charts are needed. This **ease of operation** enables normally skilled personnel to perform much of the work and still save many hours both in setting-up time and in measurement time.

Patent applied for.

For complete information on the VM-1 Attenuation Measuring Systems, call or write the Application Engineering Department, Weinschel Engineering Company.

Typical example of time saved for making eight 10 db step measurements of signal generator output attenuator or an external variable attenuator:

	Old Method		Using Weinschel VM-1	
	Time	Personnel Required	Time	Personnel Required
Set-up time for one frequency.	1 day	Highly skilled with experience	15 min.	Normally skilled operator with one week initial training.*
Measurement time	30 min.	Highly skilled with experience	3 min.	No technically skilled operator required.

* Installation and training at customer's laboratory by a Weinschel specialist is included with each system purchased.

Typical Uses of the VM-1

The VM-1 attenuation measurement system is designed for use in **standards laboratories**. It can also be used in **precision testing** on a 100% basis in certain **production** applications where state-of-art accuracies are required (e.g., radar fuzing systems, guidance and satellite communications systems). It is also used in the **calibration** of output attenuators of **signal generators**.

WEINSCHEL ENGINEERING

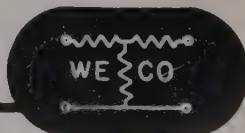
KENSINGTON, MARYLAND
December, 1961

Phone: LOckwood 4-0121

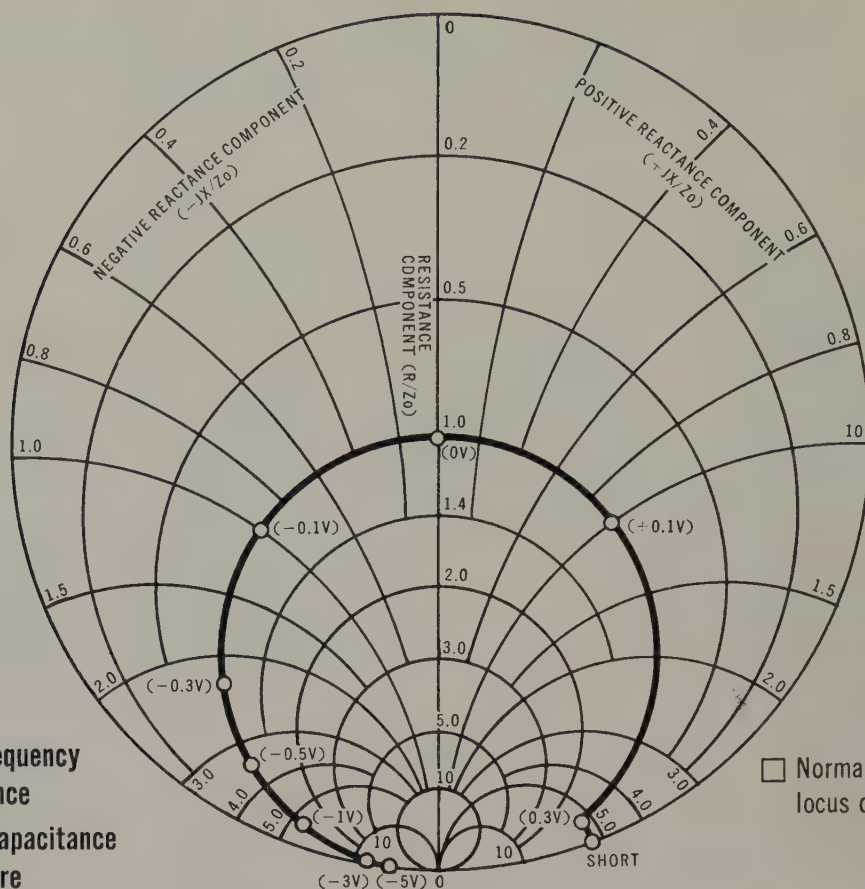
TWX: KENS 446

Circle Reader Service Card 50

®



NEW TYPE VARACTOR DIODES



with high cutoff frequency
high conductance
low junction capacitance
low noise figure

□ Normalized impedance locus of GSB1 at 6 kMc

A series of Silver Bonded diodes, developed by Mr. Shoichi Kita at the NTT Laboratory, is now in commercial production at NEC. The Kita Diode is a bonded contact type using a silver whisker with a small gallium content.

Advantages over other varactor diodes include low junction capacitance with high cutoff frequency, resulting in low pumping power. Junction capacitance of GSB1A, for example, is rated at .30 $\mu\mu\text{f}$ max.

These new diodes are designed for use in parametric amplifiers (GSB1), high-power upconverters (GSB2) and other uses in frequency multipliers, amplitude limiters, microwave harmonic generators, ultra-fast switching, and microwave switches.

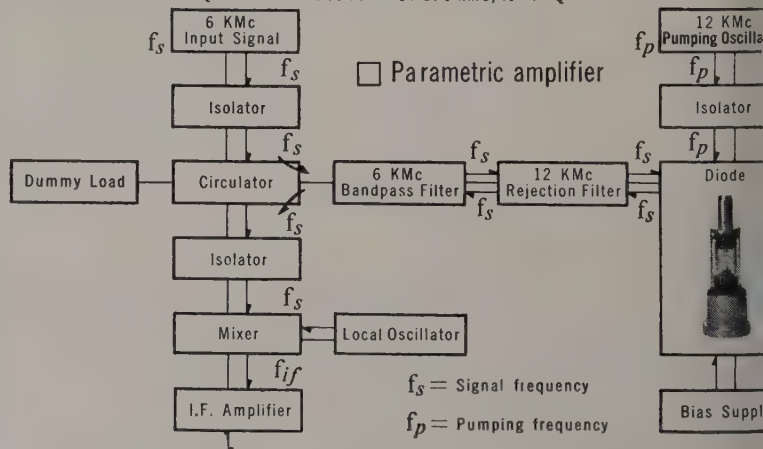
Other features common to all types: Stability of reverse current in 2,000-hour tests measures $\pm 5\%$ ($T_{stg} = 90^\circ\text{C}$). Hermetic glass-to-metal seal. MIL outlines. Reversible polarity with detachable base adapter.

Immediate shipment in commercial quantities is now possible—and at prices well below those of comparable diodes. Please write for details.

Electrical Characteristics

Type	GSB1A	GSB1B	GSB2
Forward current at 1V (min) (mA)	100	100	70
Inverse current at -1V (max) (μA)	1.5	1.0	1.0
Breakdown Voltage at -50 μA (min) (V)	6.0	6.0	11.0
Junction capacitance at zero bias ($\mu\mu\text{F}$)	.30 (max)	.30 (max)	.30 (typical)
Cutoff frequency * (kMc)	60 (min)	100 (min)	40 (typical)

* f_c is calculated from Q measurement at $V_b = -5\text{V}$ at 6 kMc, $f_c = f \cdot Q$



Typical GSB1 application data for parametric amplifier, 25°C .

Signal frequency... 6 kMc Amplifier gain... 18 db Pumping power... 5
Pumping frequency... 12 kMc Noise figure... 2.5 db (double sideband)

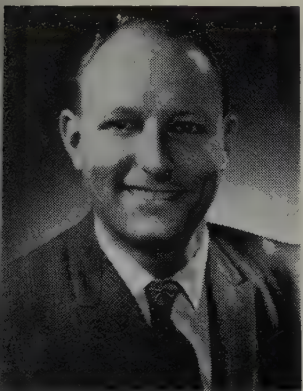
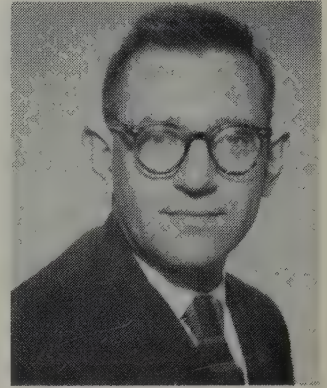
CONTRIBUTORS IN THIS ISSUE

ARON D. BRESLER attended the City College of New York (BEE, 1944) and the Polytechnic Institute of Brooklyn (DEE, 1959).

Following four years service with the U.S. Army Signal Corps, he taught at C.N.Y. (1948-51, 1953-55) and was on the staff of the P.I.B. Microwave Research Institute (1951-53, 1955-59) where he engaged in development work on microwave components and in analytical studies of propagation and diffraction phenomena in isotropic waveguides.

Since 1959, he has been a member of the staff of Jasik Laboratories, Inc., Westbury, N.Y., where he is engaged in the design and development of antennas and associated components.

Dr. Bresler is a senior member of the IRE, a member of the editorial board of the PGMTT, and a member of Sigma Xi, Tau Beta Pi and Eta Kappa Nu.



ROBERT C. HANSEN was born in St. Louis, Mo., in 1926. His schooling at the Missouri School of Mines and Metallurgy was interrupted in 1944 for a period of U.S. Navy service as an RT and electronics instructor. He was an honor student at the school of Mines and obtained a BS degree in electrical engineering. He received MS and PhD degrees from the University of Illinois in 1950 and 1955.

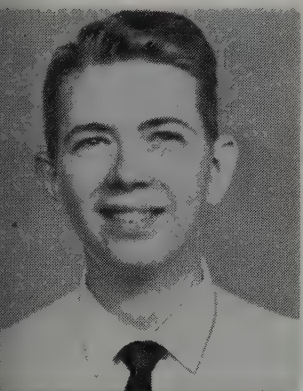
Presently, Dr. Hansen is Senior Staff Scientist in the Electronics Research Laboratory of Aerospace Corporation. Previously, he was Senior Staff Engineer in the Microwave Laboratory of Hughes Aircraft Company and a Senior Staff Engineer in the Telecommunications Laboratory of Space Technology Laboratories, Inc.

He is a member of the American Physical Society, Tau Beta Pi, Sigma Xi, Eta Kappa Nu, Phi Kappa Phi, Commission VI of URSI, a registered Professional Engineer in Missouri, and an associate editor of *the microwave journal*.

HENRY JASIK was born in New York City in 1919. He received a BSEE degree from the Newark College of Engineering in 1938 and a DEE degree from the Polytechnic Institute of Brooklyn in 1953.

He was engaged as an electronics engineer with several industrial and government organizations for a period of 15 years. In 1953, he became an independent consultant. Several years ago, he organized Jasik Laboratories to carry out research, development and production in the field of antennas and associated microwave components. He is currently president and general manager of this organization.

Dr. Jasik is a fellow of the IRE, a member of Eta Kappa Nu and Sigma Xi, a registered Professional Engineer in the state of New York, and an associate of *the microwave journal*.



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During 1957 and 1958, he was engaged in plasma and backscattering studies at Convair, San Diego, Cal. In 1958 he joined the Hughes Aircraft Company, Culver City, California, where he was engaged in the research and development of parametric amplifiers.

In 1960 he joined Texas Instruments Incorporated, Dallas, Texas, where he has since been engaged in research and development of parametric amplifiers.

(Continued on page 77)



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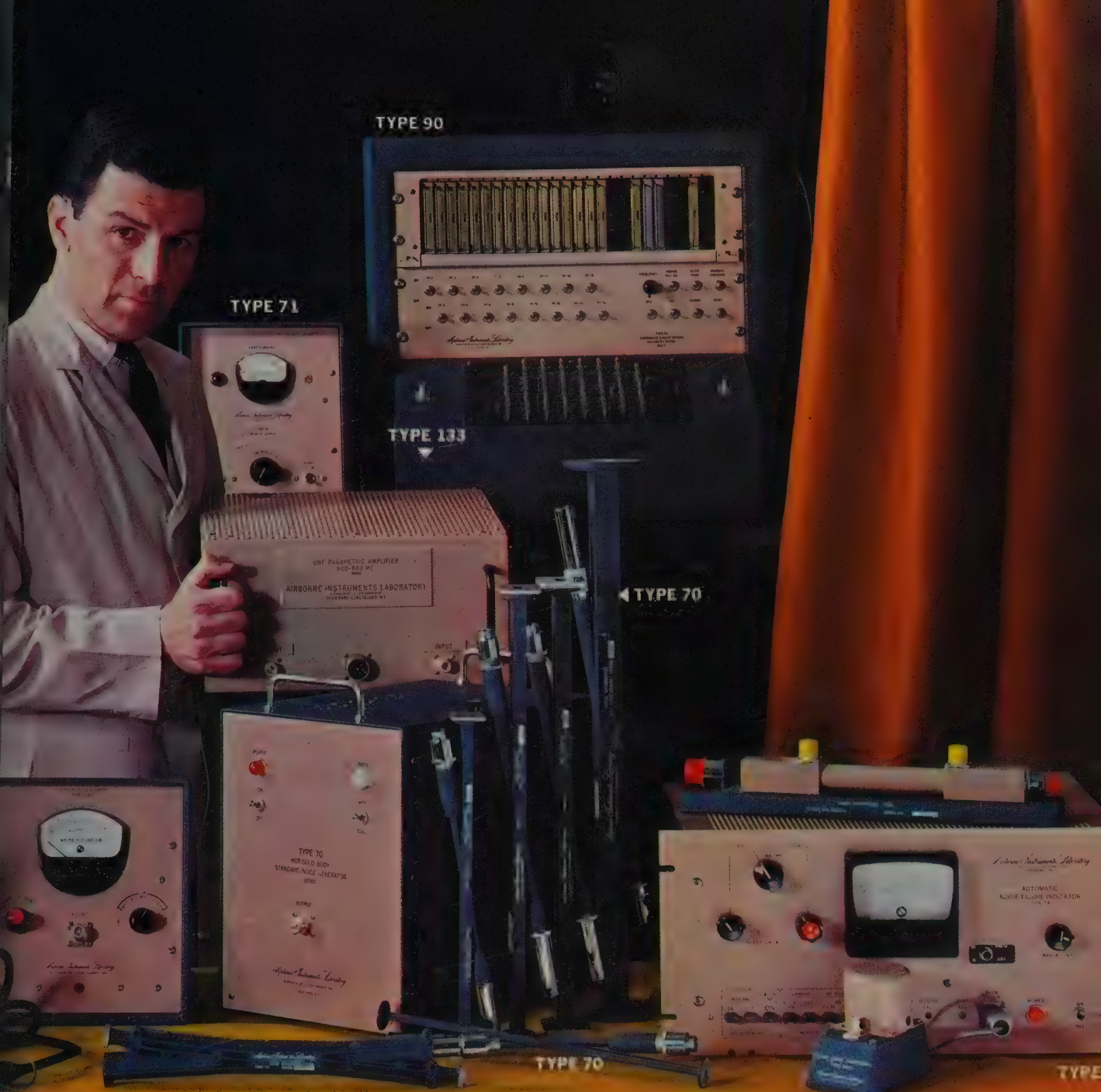
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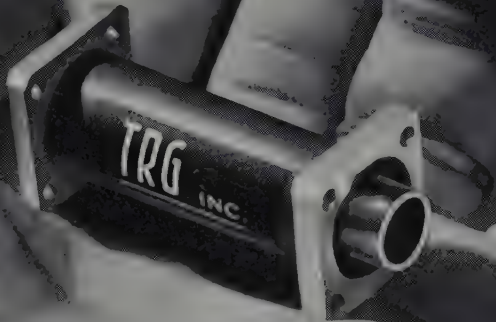
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the microwave journal

(Continued from page 73)

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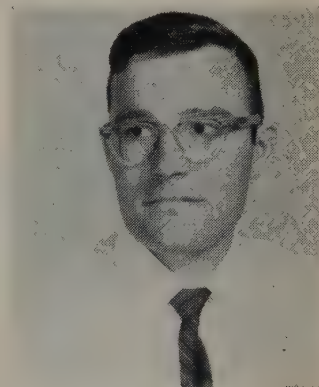
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Mr. Kampinsky is a member of the IRE.

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As an engineer at the Sylvania Electronic Defense Laboratory, Mountain View, Cal., from July 1958 to July 1961, and as a Senior Engineer at Ryan Electronics, San Diego, Cal., his present position, Mr. Reindel has been principally engaged in the design and development of microwave components.

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K. A. STEELE was born in Regina, Saskatchewan, on May 4, 1928. He attended the University of Manitoba and received a BS degree in electrical engineering in 1953.

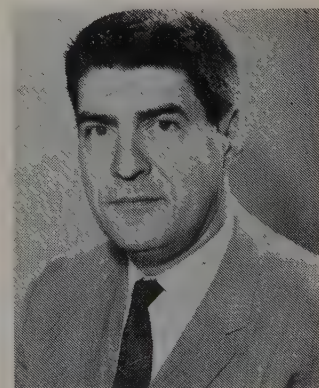
Since 1953 he has been employed with the Radio and Electrical Engineering Division of the National Research Council of Canada, where his work has been primarily concerned with defense problems.

Mr. Steele is a member of the IRE and the PGMTT.

RICHARD G. STEPHENSON was graduated from Oberlin College with a B.A. degree in physics and has continued advanced studies in nuclear physics at Cornell University.

He joined Aerospace in 1961 following approximately five years with Space Technology Laboratories and its parent company, the Ramo-Wooldridge Corporation. Positions he held at STL included Senior Staff Engineer in the Telecommunications Laboratory; head of the Space Communications and Tracking Section; and Manager of the Hawaii Tracking Station.

Mr. Stephenson is the holder of a patent on a servo control system for ship-board Sonar, two patents on Sonar signal detector circuits, and has patents pending on secured Sonar communications and a digital programming device. He is a senior member of the IRE.



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COMMUNICATIONS AT MEGAMILE RANGES[†]

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Editor's Note — The following paper was presented at the 1961 Convention of the British Institution of Radio Engineers. The Convention had the theme "Radio Techniques and Space Research" and was held at Oxford 5-9 July. The paper appeared in the October 1961 issue of the Journal of the British IRE and is reprinted here with their permission. Other papers presented at the Convention cover topics of radio techniques in space research, satellite components, satellite engineering, satellite systems, and extraterrestrial measurements and radio astronomy, and may be found in the October and November issues of the Journal.

FIRST OF TWO PARTS

INTRODUCTION

This paper reviews the major compromises that arise in the design of a deep space communications system. Section II covers the factors in ground receiving station performance. Graphs are presented for the noise temperature contribution of several sources including the galaxy, radio stars, atmospheric absorption, ionospheric refraction and Faraday rotation, and earth radiation through the antenna sidelobes. Transmission line losses and high-gain antennas are also covered. Section III discusses system calculations and digital modulation techniques. Biphasic systems are compared with more sophisticated orthogonal systems. Also covered are the principles of a narrow-band phase-lock receiver and of a coherent demodulation system for binary bits. Section IV describes the Pioneer V communication system.

I. LOW NOISE, HIGH GAIN GROUND STATIONS

It is convenient to discuss system performance in terms of a system noise temperature rather than the easily misinterpreted noise figure or noise factor. The system noise temperature is of course the temperature of the input resistive termination of a hypothetical noiseless system which provides the same output noise power as the actual system. Below about 50 Mc atmospheric noise is usually the limiting factor. At lower frequencies, the effective antenna temperature (defined below) due to atmospheric noise can easily be 10^3 degrees K or higher. Above this frequency, atmospheric noise is negligible and other noise sources become important. The noise appearing at the antenna terminals originates from a multitude of sources. We will attempt to categorize the most important sources. These are galactic noise, star and planetary noise, atmospheric absorption noise, and earth radiation. Man-made noise is not included here. All of these may contribute noise through the antenna main beam or

through the sidelobes. In addition, resistive loss in the antenna and transmission line structure introduces noise.

At frequencies above one Gc (and to a lesser degree below one Gc) the spatial distribution of noise is not isotropic and the antenna pattern is typically highly directional. In addition, the multitude of sources poses a problem. For example, the antenna may see one noise source partially reflected in the surface of a second noise source; e.g., land or sea. Reciprocity allows us to say that the noise received by the antenna from each direction (through a small solid angle) is proportional to the power absorbed in that direction when the antenna is transmitting, multiplied by the ambient temperature of the absorbing body. This is given by equation (1), where the effective antenna temperature T_a due to a source of temperature T_s , subtending small solid angle θ_s^2 is given. G is the antenna gain averaged over the solid angle θ_s^2 .

$$T_a = \frac{\theta_s^2 T_s G}{4\pi} \quad (1)$$

Typically the antenna main beam and sidelobes are divided up into a number of small solid angle regions, according to the distribution of noise sources. Formula (1) is then used to find the contribution to antenna temperature from each, with gain for each solid angle used in (1). For a noise source subtending angle θ_s , with $\theta_s \geq \theta_a$ where θ_a is the antenna beamwidth, the gain in (1) is now the maximum gain or the directivity, given for an ideal antenna as

$$G = \frac{4\pi}{\theta_a^2} \quad (2)$$

This equation coupled with (1) gives a main beam noise temperature contribution from a source $\theta_s \geq \theta_a$ of $T_a = T_s$.

* Formerly at Space Technology Labs, Inc.

[†] Reprinted from the Journal of the British IRE, vol. 22, October, 1961, pp. 329-345.

To this must be added the sidelobe contribution if $\theta_s > \theta_a$. For the case where $\theta_s < \theta_a$ and the beam maximum is pointed at the noise source, (2) holds, giving with (1)

$$T_a = T_s \left(\frac{\theta_s}{\theta_a} \right)^2 \tag{3}$$

The details of how to calculate antenna temperatures for a narrow-beam antenna looking at a multitude of sources have been given by one of the authors.¹ It will suffice here to detail the magnitude and variation of the important constituents so that the boundary of the problem may be delineated. This is of special interest in the selection of an optimum frequency which will be discussed later.

Galactic Noise

Information on cosmic or galactic noise has appeared from many sources. The most extensive are the charts of Menzel² which cover the heavens at 200 and 600 Mc and the paper of Ko³ which gives charts from 64 Mc to 910 Mc. Menzel's data were measured with a 10° pencil beam, producing a somewhat coarse mapping; Ko summarizes data from a variety of sources. Other sources give data for a 20° beam.⁴ Figure 1 shows a typical distribution of galactic noise temperature (in degrees Kelvin) for 378 Mc; this was the frequency of the Pioneer V telemetry link from vehicle to earth. These data have been obtained by using the 250 Mc contours of Ko, scaling the intensities by

$$T \propto f^{-2.5}$$

as determined empirically by Hanbury Brown and Hazard⁵. The coordinate system is one commonly used by astronomers, with right ascension (hour angle) for the abscissa and declination as the ordinate.

In general, our sun is a small star in one arm of a spiral "pancake" galaxy. Antennas pointed in the direction of the galactic center see many sources, hence have a high antenna temperature; another peak not quite so large occurs when the antenna looks along the galactic arm. When, however, the antenna looks out of the galactic plane, the noise temperature is very low. The galactic center and arm can be observed in Figure 1, along with

the low values out of the plane. Examination of this figure and of Ko's plot at 910 Mc indicates that only a few localized regions contribute appreciable antenna temperature. At higher frequencies this is even more true. For the galactic center, Hanbury Brown and Hazard quote 17° K for 1.2 Gc with a 2.8° beam, and 2.6° K for 3 Gc with a 3.4° beam. Thus above one Gc the continuous background is very low; a list of discrete sources is valuable.

Discrete Sources

Of the discrete body sources, the sun is certainly the shining example. Hogg and Mumford⁶ have given the noise temperature contribution of the sun for antennas whose beamwidth is not greater than the 0.5° plane angle subtended by the sun. Their data are shown in Figure 2. For antennas of broader beamwidth, the antenna temperature T_a is decreased by equation (3) when $\theta_s = 0.5^\circ$. For radio stars, the flux density S is given by

$$S = \frac{2k T_s \theta_s^2}{\lambda^2} \text{ wm}^2/\text{c.p.s.} \tag{4}$$

where T_s and θ_s are the star temperature and subtended angle, and k is Boltzmann's constant. For almost all stars $\theta_a \geq \theta_s$; combining (3) with (4) one obtains antenna temperature contribution as a function of antenna effective aperture A_e and flux density:

$$T_a = \frac{S A_e}{2k} \tag{5}$$

Ko⁷ gives a list of 57 "reliable and intense" radio stars; he also gives flux density vs. frequency data on 11 of the more prominent sources. For example, the data on Cassiopeia A are shown in Figure 3. From Ko's data we have prepared Figure 4, a plot of the more prominent radio stars, again on a right ascension-declination coordinate system. The temperatures shown have been computed as the effective noise temperature when observed with the 250 foot parabolic antenna at Jodrell Bank; a 40 db aperture gain factor at 400 Mc has been estimated (similar to the Pioneer V measurements, the instrument has been improved).

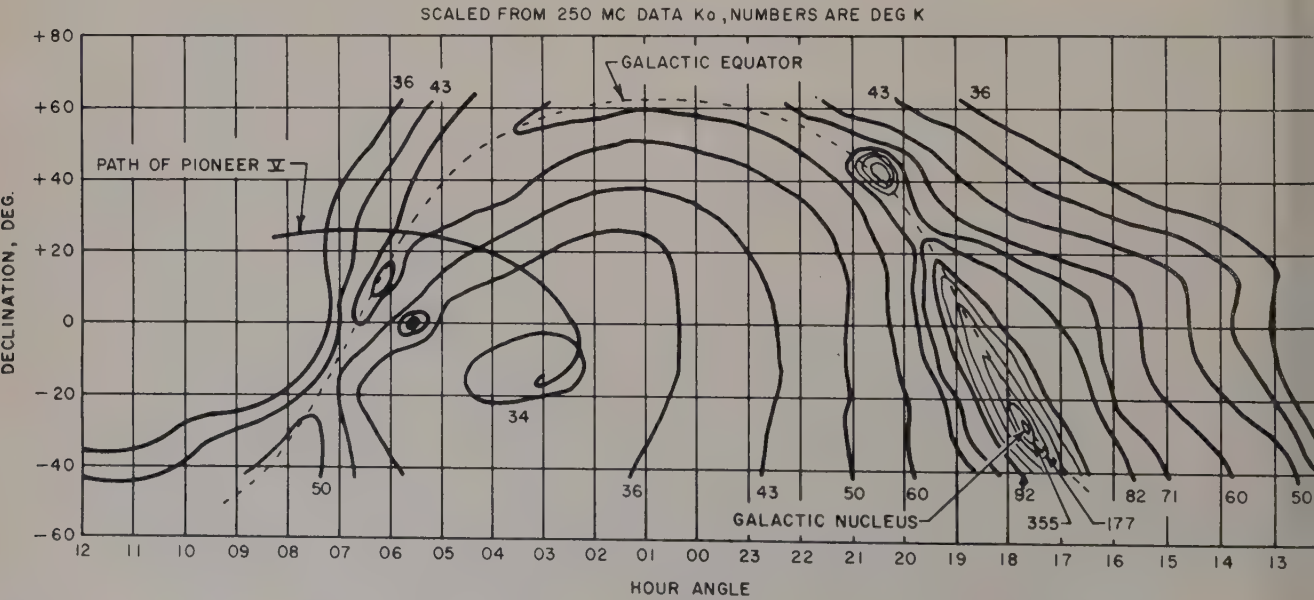


Figure 1 — Cosmic background radiation at 378 Mc.

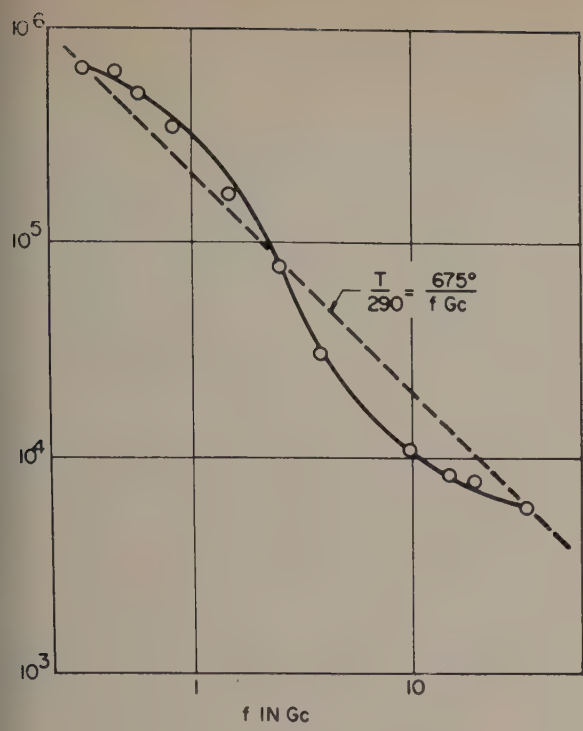


Figure 2 — Sun noise temperature.

For very low noise systems, weaker radio stars as well as planets must be considered. Table I shows approximate temperatures for the most important planets.⁸⁻¹¹ Equation (1) is also used to calculate planetary contributions to antenna temperature.

TABLE I Planetary Radiation Temperatures		
	Frequency Gc	Surface Temperature deg K
enus	35	410
	9.5	590
	3	580
	9.5	145
upiter	2.9	640
	1.4	3000
	.97	5500
	.44	50,000
	9.5	218
ars		

Atmospheric Absorption

In addition to noise from extraterrestrial sources, noise can be introduced into a receiving antenna system because of absorption of radio signals by oxygen, water vapor, and rain. This noise, due to the attenuating qualities of the atmosphere, should not be confused with the 'atmospheric noise'; this latter term is commonly used to denote low-frequency noise mainly due to lightning. The effects of rain have been indicated by Hogg and Semplak¹², who observed increases of sky temperature from 3° K to 70° K (120° K during storms) at 6 Gc. Atmospheric absorption is computed for the international standard atmos-

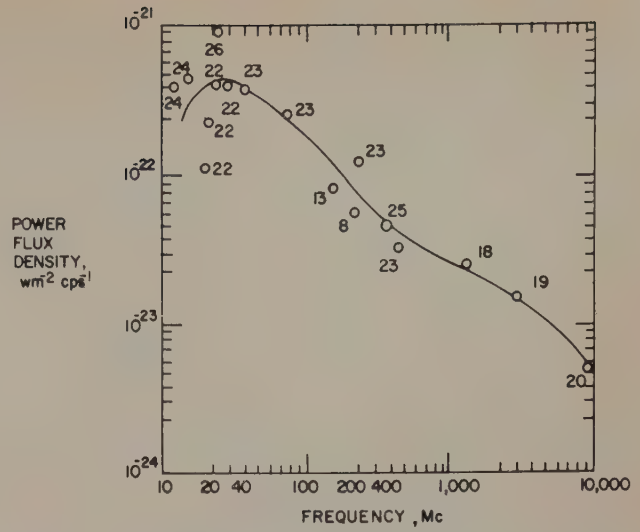


Figure 3 — Radio spectrum of Cassiopeia A (IAU23N5A). (The numbers indicate observers.)

phere, unless more specific data are available; the summer standard atmosphere is shown in Figure 5. The actual noise contribution depends upon the absorption coefficient of the atmosphere, upon the actual temperature of the atmosphere, and upon the antenna elevation angle. Data on atmospheric absorption in the lower portion of the microwave region are given by Hogg and Mumford,^{6,13} (see Figure 6), while recent results on millimetric absorption have been given by Tolbert and Straiton¹⁴ and by Rosenblum¹⁵. Translated for a low sidelobe hog-horn antenna, the attenuation results in the temperature versus frequency curve of Figure 7 where elevation angle is a parameter. To this effect should be added the ionospheric attenuation¹⁶, which is shown in Figure 8. It will be noted that attenuation in the ionosphere is negligible above about 300 Mc, while the tropospheric curves, given earlier, are smaller below that frequency. The reader is cautioned that these data are "typical" and cannot be relied upon for exact values on a specific experiment.

All of these sources contribute principally through the antenna main beam. The sidelobes are an important noise source, however, in that sidelobes look at such hot sources as the sun and the earth (the earth may not be as hot, but it looks much bigger). Noise temperature is

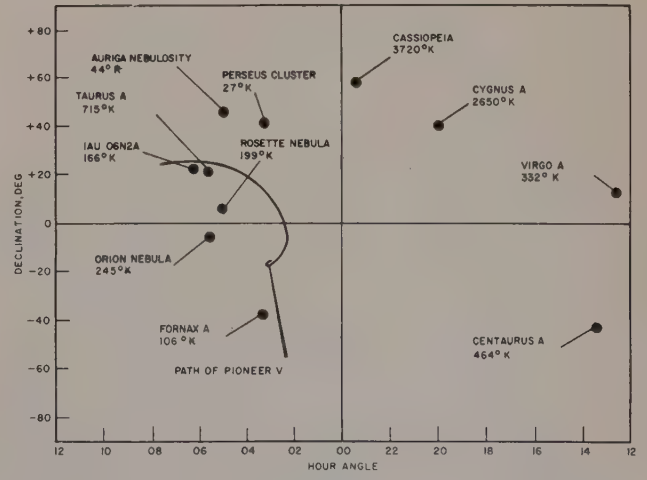


Figure 4 — Stellar radio sources at 378 Mc for Manchester antenna.

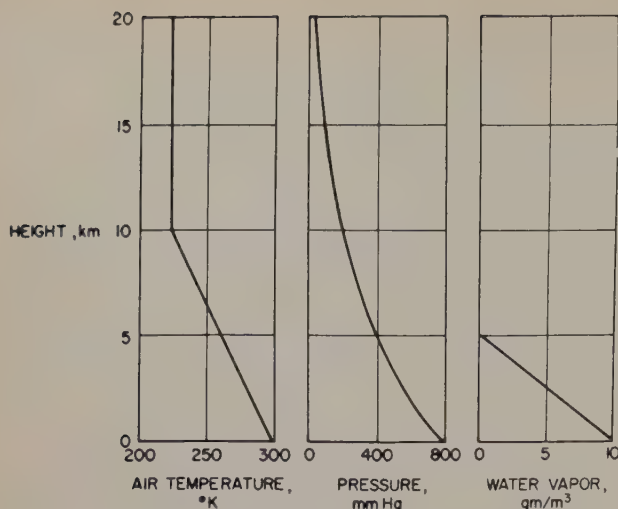


Figure 5 — International standard atmosphere.

calculated¹ by multiplying the fraction of power contained in each sidelobe by the average temperature that the sidelobe sees. These temperatures are then added to the main beam contributions. When a sidelobe looks at the sun, formula (2) is used.

Transmission Line Loss

Between the incident electromagnetic wave and the receiver terminal there appear a number of metal structures including the antenna, transmission lines, duplexers, etc. Resistive losses in all of these introduce noise as well as signal attenuation. Very small losses in structures at room temperature can best be handled by adding 7 degrees K for every 0.1 db; losses higher than a few tenths db should be treated as a four terminal network. When the attenuation ratio (input to output) is called L , the noise temperature at the output of the transmission

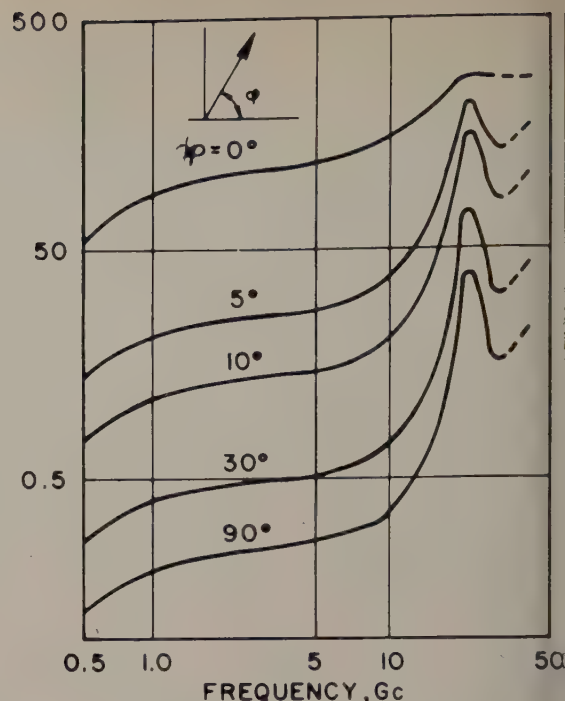


Figure 7 — Antenna temperature (after Hogg & Mumford)

line is given by the following formula, where T_a is the antenna temperature and T_L is the ambient temperature

$$T_{out} = \frac{L-1}{L} T_L + \frac{1}{L} T_a \quad (6)$$

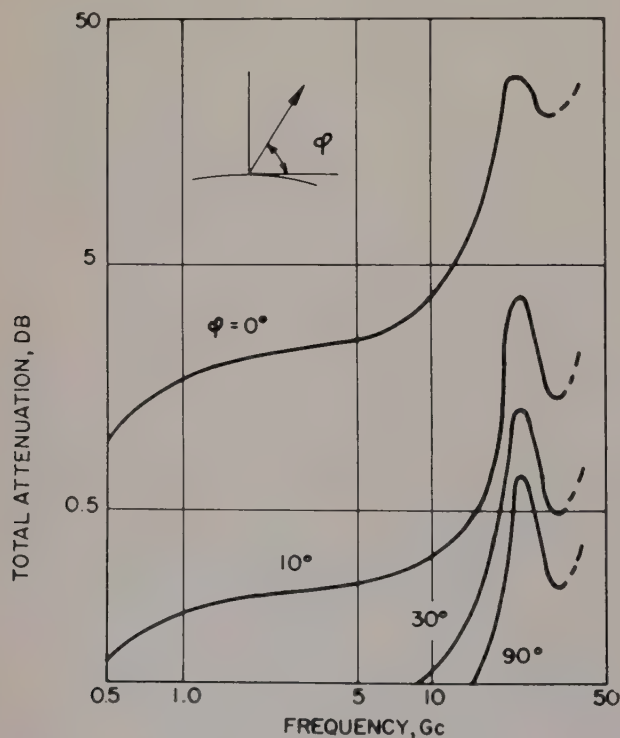


Figure 6 — Absorption through troposphere.

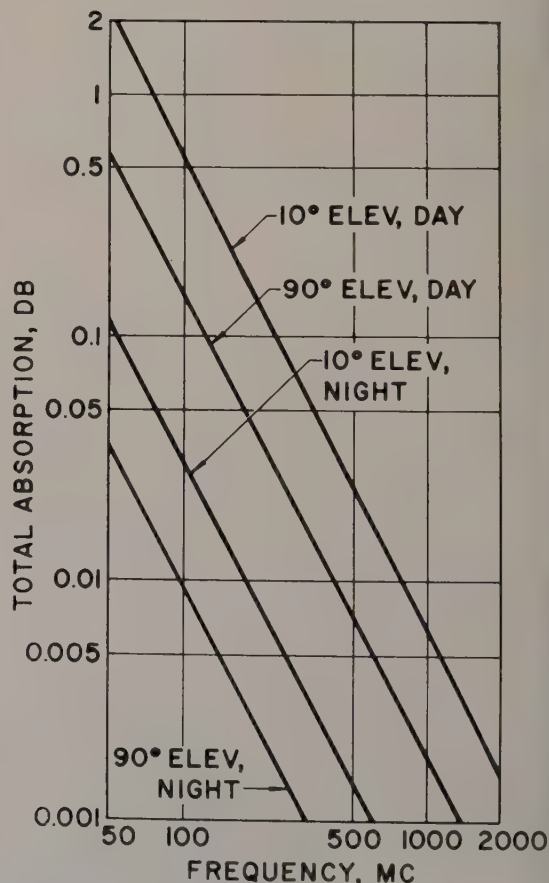


Figure 8 — Absorption through ionosphere for source at 10 Km height.

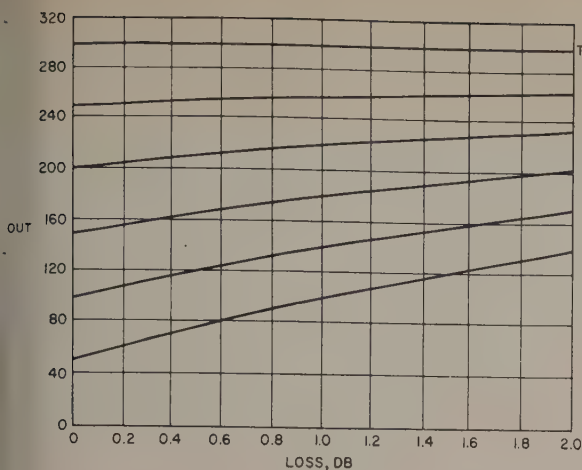


Figure 9 — Output temperature vs. line loss.

Figure 9 depicts the variation for an ambient of 290°K. For an antenna temperature of 50 degrees K for example, one db of loss raises the input temperature to 100 degrees K resulting in an appreciable degradation in system sensitivity. In addition, the signal itself is attenuated by one db.

Refraction

The effects of tropospheric refraction, which are independent of frequency, are plotted in Figure 10. The shaded area shows the variation of the ray-bending by the troposphere under widely varying conditions. In this figure one sees that errors in elevation angle are appreciable only if the elevation angle is very low. The data in this figure summarizes a number of specific calculations on tropospheric refraction. However, the bulk of the data were obtained from Weisbrod and Anderson.¹⁷

Ionospheric refraction is very small for uhf signal rays from ground to outer space, and can be neglected in comparison to the tropospheric effect for frequencies above 100 Mc. (However, the refraction cannot be neglected for sources within the ionosphere.)

Faraday Rotation

Faraday rotation of the plane of polarization of radio waves must also be recognized during the design of a

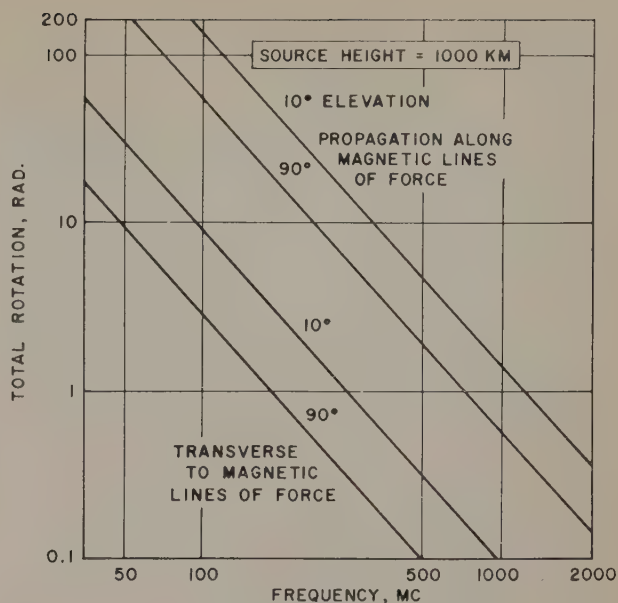


Figure 11 — Daytime Faraday rotation.

space communication system. This rotation phenomenon is caused by an interaction of the earth's magnetic field and free electrons in the ionosphere. Figure 11 shows the number of radians of rotation of incoming radio signals as a function of frequency and of elevation angle, as calculated by Millman.¹⁶ From that figure, we see that rotation experienced is markedly different according to the direction of the magnetic field. Propagation along a magnetic field line of force can cause a rotation of about 15 radians for 378-Mc signals at low-elevation angles during the daytime; propagation in a direction perpendicular to magnetic lines of force will cause a rotation of only about 1.0 radian. Nighttime effects are about one third of those shown.

The Faraday rotation is important to consider if linearly-polarized antennas are to be used for both transmission and reception of signals from space probes. As the transmission ray moves across the sky, and as the condition of the ionosphere changes, the magnitude of the Faraday effect will change; thus, the receiving signal plane of polarization will change with time. If a linearly-polarized receiving antenna is used for such signals, the

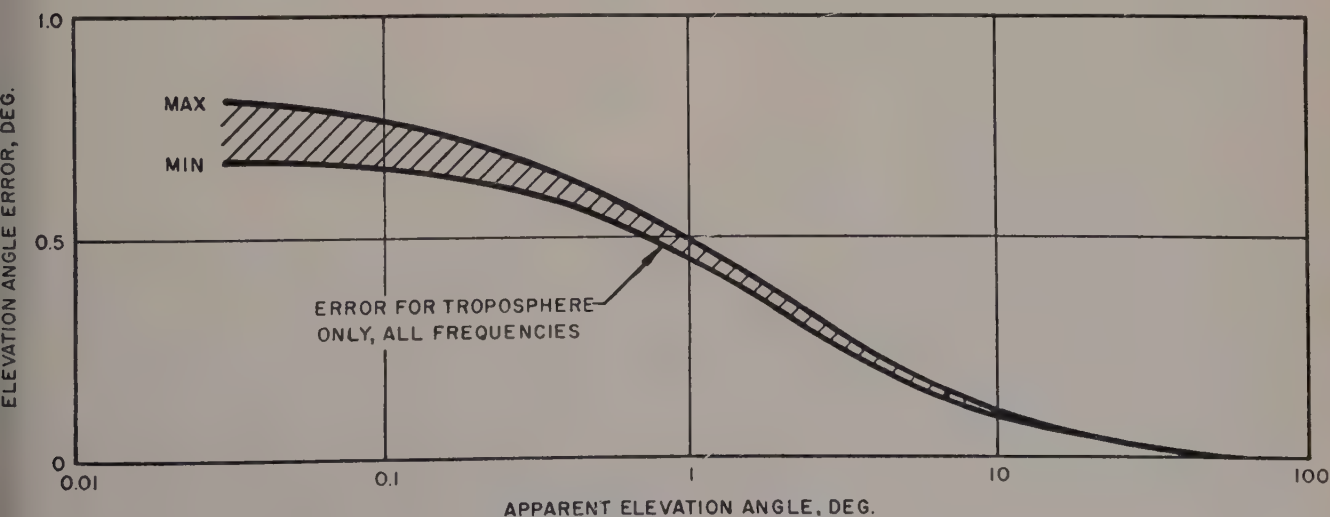


Figure 10 — Atmospheric refraction errors.

receiving antenna plane of polarization must be rotated continually to maintain a strong receiving signal; if this is not done, the signal will fade severely as its plane of polarization becomes perpendicular to that of the receiving antenna. Because continual rotation of a dipole feed on a parabolic antenna is an unattractive requirement, it has become common to use circularly-polarized receiving antenna feeds. Such a feed will have 3 db less gain than a linear feed for linearly-polarized incoming signals; however, the signal amplitude from such a feed will be steady and signal dropouts can be avoided. This effect decreases rapidly with increasing frequency; above 2 Gc, antennas of the same polarization can be used (if vehicle orientation permits).

Antennas

In considering various components of the system, the interesting question arises of how high a gain is practical in parabolic antennas. Data on the performance of a number of large parabolic antennas were gathered with the interesting result that none of the large group of antenna systems which were investigated has achieved gains above 65 db. This apparent present limitation on gain appears to be caused by mechanical imperfections in the surface of the parabolic reflector. Some large antennas may have gain restrictions substantially below this limit of 65 db where mesh rather than solid-surface parabolas are used, or where the structural rigidity is insufficient to preclude elastic deformation as the dish is tilted. A gain limitation due to tropospheric irregularities or 'blobs' may be introduced at higher gain levels.¹⁸

Typical aperture gain factors are 50% for parabolic dish tracking antennas. The directivity G is given by:

$$G = D^2 f^2 (7.2 \text{ db}) \quad (7)$$

with D in ft, f in Gc, where the constant in parenthesis is to be added to the other quantities expressed in db. (This shorthand allows visualization of the compact equation, while allowing the constant to be expressed in db.) Many other types of antennas, e.g., helices and helical arrays, have been used as well as parabolic dishes. The most vital parameter is antenna directivity; as the next section will show, the directivities must be as large as possible. For the critical space-to-earth link, there is a limit on system noise temperature. Greater ranges/data rates require higher vehicle power, higher vehicle antenna effective area, or higher ground antenna effective area. Thus larger and larger ground antennas or arrays of large antennas are to be expected.

Another very practical consideration in the use of high-gain antennas is that of signal acquisition with a very fine pencil beam. A parabolic antenna whose gain is 60 db will have a total beamwidth of 0.14° and thus require steering information accurate to 0.07° , or roughly one mil. Prediction of signal azimuth and elevation to such accuracy is very difficult for most space probes because of uncertainties in trajectory data, and also because the atmospheric refraction may be large compared to such a tolerance. Thus use of very narrow beam antennas poses some difficult operational problems.

III. SYSTEM CALCULATIONS

Range Equation

The one-way range equation is given by

$$P_T = \frac{16\pi^2 R^2 P_R}{G_1 G_2 \lambda^2} = \frac{16\pi^2 R^2 kTB S/N}{G_1 G_2 \lambda^2} \quad (8)$$

This formula can be rewritten in a more useable form as

$$P_T = \frac{R^2 f^2 T B S/N}{G_1 G_2 (130.8 \text{ db})} \quad (9)$$

Units used are the following:

P_T = Transmitted power in watts

G_1 = Ground antenna directivity

G_2 = Vehicle antenna directivity

B = Bandwidth in cycles

T = Over-all system noise temperature*, degrees K

f = Frequency, gigacycles

R = Range, n. mi.

S/N = Signal-to-noise ratio

Path loss is a useful concept, and it consists of part of equation (8) above. It is

$$\text{Path Loss} = \frac{16\pi^2 R^2}{\lambda^2} = R^2 f^2 (97.8 \text{ db}) \quad (10)$$

using the units above.

Figure 12 has been drawn to show the total path loss, including two antennas, over a distance of one million nautical miles for three types of antenna systems. It can be seen that the loss between two dipoles increases with the square of frequency. The dish antennas have assumed an aperture gain factor of 50% for frequencies up to 3.1 Gc where the hypothetical 250 ft antenna has 65 db directivity. Above this frequency the 250 foot antenna is assumed to have an arbitrary maximum directivity of 65 db; this accounts for the 'corners' in the ideal curves of Figure 12. These data emphasize the need for high antenna directivities (large antennas).

The antenna gains and noise temperatures have already been discussed. The remaining two items of interest are the choice of frequency and the signal-to-noise behavior. Although the Pioneer V frequencies were chosen on the basis of compatibility with existing systems, it is not inappropriate to discuss the behavior of system performance with frequency. There are generally three prime

* In many formulas for both one-way and two-way range equations, one often sees the noise power kTB replaced by the approximate $kT_o B F_N$ where T_o is $290^\circ K$ and F_N is the system noise figure defined as

$$F_N = 1 + \frac{T}{T_o}$$

The approximation is good only for high-noise systems and becomes very misleading for low-noise systems. The correct result for noise power, of course, is $N = kT_o B (F_N - 1) = kTB$. However, it is much simpler to use noise temperature as the antenna and loss contributions are readily available in that form as are the parameters for low-noise preamplifiers.

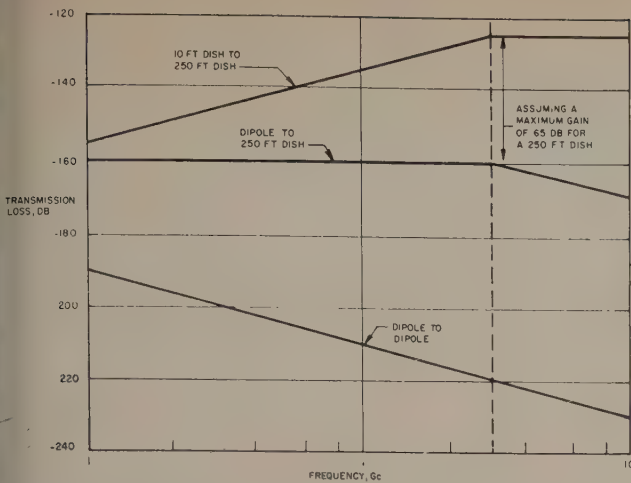


Figure 12 — Path loss and antenna gain for one nautical megamile.

considerations. These are the sharp rise in galactic noise below one Gc (and unacceptable incidence of atmospheric noise below 100 Mc), severe atmospheric absorption above 15 Gc, and the declining efficiency of both tube and solid state transmitters as frequency goes towards 10 Gc. Beamwidth of large aperture antennas may be a problem above 2 Gc. Thus one may generally state that optimum frequencies for deep space communications lie in the range one to 10 Gc. Within this range one may derive an optimum region by assuming cost functions for vehicle antenna directivity, vehicle transmitter power, etc. A number of papers have appeared in the literature essentially doing this. Most of these factor in the variation of antenna noise temperature with frequency, and make assumptions about vehicle antenna, vehicle transmitter, ground antenna, etc.¹⁹⁻²² Most of these studies arrive at an optimum somewhere in the middle of the range mentioned above, but it should be emphasized that the set of assumptions will be different for each case, hence the optimum frequency will also vary. Davies and Weaver²³ have derived optimum performance for a fixed vehicle weight as a function of range and bandwidth. Others have assumed an upper limit to ground antenna gain.²⁴⁻²⁶ Raisbeck²⁷ has considered the case where the system attenuation (noise temperature) is a function of frequency. Since the actual choice of frequency is usually dictated by a host of quasitechnical factors such as frequency allocations, many of the above references are of academic interest only.

Another item that is sometimes of importance is the splitting of spectral lines due to satellite spin. An excellent paper by Bolljahn²⁸ contains the necessary formulas for calculating these effects. This effect, however, does not affect phase coherent two-way systems.

Instead of using the vehicle antenna as a two-part transducer, an attractive scheme uses an active automatic angle return array. In this scheme the Van Atta array, which is an array of cross-connected elements with the interesting property that energy is radiated in the direction of the incident energy, is made active by use of solid state printed circuit amplifiers. The advantages of the active Van Atta system are the realization of two-way antenna gain over $\pm 45^\circ$ without vehicle stabilization, and intrinsic high reliability. The interested reader is referred to the literature for further details.²⁹

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Part II of Dr. Hansen's paper will appear in the January issue of *the microwave journal*.

IMPROVING THE GAIN STABILITY OF PARAMETRIC AMPLIFIERS

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Introduction and Summary

Reflection-type, negative-resistance parametric amplifiers are beginning to find wide use in radar systems and microwave links. As their applications broaden, it becomes increasingly important to improve upon what is perhaps the most serious shortcoming of these devices—poor gain stability. Of course, the gain stability of parametric amplifiers is the product of a variety of factors but many of these factors can be controlled or minimized; and a very stable amplifier can be constructed.

This paper is a discussion of parametric amplifier gain stability. Specifically, it (a) reviews the factors that limit it, (b) describes several ways to maximize it, and (c) presents a method whereby it can be determined. It is shown, for example, that parametric amplifiers can be made stable to input VSWR changes if they are operated at fairly low gain, and if a circulator with sufficient isolation is used. It is also shown that gain fluctuations caused by pump power variations can be minimized by using a stable pump source and by having a low-Q pump circuit within the amplifier.

Other stability-increasing methods discussed: the use of a diode that has a series resistance with a flat, function-of-temperature slope over the desired temperature range; and compensation of center frequency shift by means of a second diode that controls bias and holds capacitance at a constant value. Finally, though not discussed here, one of the simplest ways to increase gain stability is to use a broadband parametric amplifier, since it is less sensitive to temperature change than a narrowband amplifier.

General Expressions

The parametric amplifier equivalent circuit to be considered is shown in Figure 1. This circuit represents a reflection-type, negative-resistance amplifier of the lowest noise figure, broadest bandwidth, and greatest stability.

To get broad bandwidths in practice, a series resonance is formed at the idler frequency.¹ This means that to achieve signal resonance it is necessary to add only an inductance, L' , at the signal frequency (assuming that the signal frequency is below the varactor series resonant frequency). Since this circuit can essentially be made a

lumped-constant structure, it provides the necessary broad bandwidths. (We will assume that this is the basic structure used, although the results obtained can be applied to almost any structure; then, too, using this equivalent circuit makes it easier to ascertain the possible sources of gain or frequency instability.)

The terms used in Figure 1 are

R_g = generator resistance

V_g = signal voltage generator

L' = inductance to resonate signal circuit

C_D = diode nonlinear capacitance

r_s = diode series resistance

L = sum of diode lead inductance and any other inductance necessary to achieve a series idler resonance

B_1 = ideal filter which presents an open circuit to the signal frequency and a short circuit to the idler frequency.

Let us now consider the basic gain equations for the circuit of Figure 1, and then consider where the possible sources of gain instability occur. (The basic derivations of the following equations have been carried out by others² and, being familiar to most readers, will not be repeated here; but since this circuit differs somewhat from other circuits discussed, in that the diode is in series, an analysis of it is presented at the end of this article for those interested.)

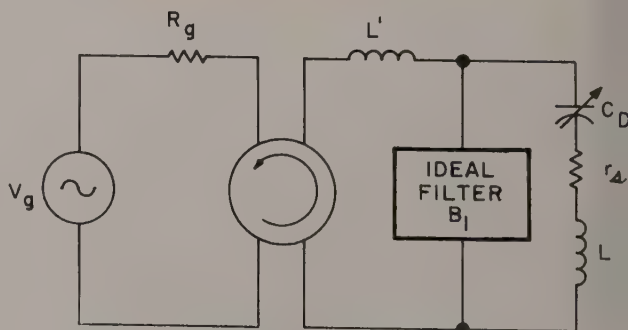


Figure 1—Parametric amplifier equivalent circuit.

The definitions used in the analysis of Figure 1 are

$n = 1, 2, 3$, as subscripts, refer to signal, idler, and pump, respectively

$\gamma = C_1/2C_0$ = Fourier capacitance ratio

$Q_{Dn} = \frac{1}{\omega_n C_0 r_s} =$ diode Q at n^{th} frequency

$R_N = r_s \gamma^2 Q_{D1}^2 \frac{\omega_1}{\omega_2} =$ negative resistance presented to signal circuit by idler circuit

G_0 = resonance power gain

$$\alpha = \left(\gamma^2 Q_{D1}^2 \frac{\omega_1}{\omega_2} - 1 \right) \frac{r_s}{R_g}$$

The reflection power gain, G , may then be shown to be

$$G = \left| \frac{1 - \frac{Z_{IN}}{R_g}}{1 + \frac{Z_{IN}}{R_g}} \right|^2, \quad (1)$$

$$G(\rho, I, G_0, 2\beta l) = G_0 \frac{\left(1 + \frac{\rho \cos(2\beta l)}{\sqrt{I}} \right) \cdot \frac{(\sqrt{G_0} + 1)}{\sqrt{G_0}} + \frac{\rho^2 (\sqrt{G_0} + 1)^2}{4G_0 I}}{1 + \frac{\rho \cos(2\beta l)}{\sqrt{I}} \cdot (\sqrt{G_0} + 1) + \frac{\rho^2 (\sqrt{G_0} + 1)^2}{4I}} \quad (5)$$

where

$$Z_{IN} = R_{IN} + j X_{IN}$$

$$R_{IN} = r_s \left(1 - \gamma^2 Q_{D1}^2 \frac{\omega_1}{\omega_2} \right)$$

$$X_{IN} = \left[\omega(L+L') - \frac{1}{\omega C_0} \right] - \frac{R_N}{r_s} \left[(\omega_s - \omega)L - \frac{1}{(\omega_s - \omega)C_0} \right];$$

at resonance the gain becomes

$$G_0 = \left[\frac{1 + \alpha}{1 - \alpha} \right]^2 \quad (2)$$

From these expressions, the following possible variables exist: input (generator) match, fluctuations in γ , variations in r_s , and C_0 as a function of temperature. Let us consider these in order.

Generator Mismatch

Probably the greatest cause of gain instability is generator mismatch. Such a mismatch can arise from several places: e.g., from a rotating antenna; from a TR tube that, when fired, presents a short circuit to the amplifier/circulator combination; or from circulator mismatches, which may vary with temperature. This last effect is a special problem that can usually be minimized by circulator modification; therefore, we shall be concerned here only with mismatches external to the circulator.

Consider a mismatch, ρ , introduced at a length of line, l , from the amplifier terminals on a transmission line of characteristic impedance R_g . The input impedance of the transmission line, Z_i , can be expressed in terms of ρ and the phase angle, $2\beta l$, in the conventional way. However, this impedance includes the generator impedance; thus, the actual impedance, Z_m , due only to the mismatch ρ , is $Z_i - R_g = Z_m$; or, in terms of ρ and $2\beta l$.

$$\frac{Z_m}{R_g} = \frac{Z_i}{R_g} - 1 = \left(\frac{1 + \rho e^{-j2\beta l}}{1 - \rho e^{-j2\beta l}} \right) - 1 \quad (3)$$

This normalized impedance now adds directly to α in Equation (2) as

$$G_0 = \left| \frac{1 + \alpha + \frac{Z_m}{R_g}}{1 - \alpha + \frac{Z_m}{R_g}} \right|^2 \quad (4)$$

The resonance gain of Equation (2) may be rewritten to include ρ . Before doing so, it should be pointed out that the isolation, I , of the circulator will divide the reflection coefficient, ρ , by $\sqrt{I}$. Thus, we may include this in the gain expression also, resulting in

Equation (5) is plotted in Figure 2 versus $2\beta l$ for $G_0=40$ and $I=400$ for various values of ρ .

It may be observed that the numerator is negligible

when compared with the denominator. In addition, the worst case occurs when $2\beta l = \pi$, in which case

$$G(\rho, I, G_0, 2\beta l) = \frac{G_0}{\left[1 - \frac{\rho(\sqrt{G_0} + 1)}{2\sqrt{I}} \right]^2} \quad (6)$$

If the mismatch ρ is fairly small, Equation (6) may be differentiated with respect to ρ so that we may write the change in gain, ΔG , as given by

$$\frac{\Delta G}{G_0} \approx \frac{\rho(\sqrt{G_0} + 1)}{\sqrt{I}} \quad (7)$$

Thus, when $G_0=40$, $I=400$ and $VSWR=1.1$, $\Delta G/G_0=1.84\%$. For larger mismatches, Equation (5) or (6) must be used.

It is evident that for minimum effect of generator mis-

match, it is necessary to have low VSWR's, high isolation, and low gains.

Effect of Pump Power Variations

Pump power variations arise from many sources such as klystron output changing with temperature or long-term klystron drift and vibrational variations. We shall now consider the effect of pump power variations that can be controlled and minimized.

The pump power is used to produce a time-varying capacitance at the pump frequency. The pump power, then, gives rise to variations in γ . It is necessary at first to find the relationship between pump power and γ .

The capacitance of a varactor is a function of applied voltage according to the equation

$$C = C_{oB}(v/V_o)^{-m}, \tag{8}$$

where

- C_{oB} = bias voltage capacitance
- $V_o = V_B + V_D$
- V_B = bias voltage
- V_D = contact potential
- $m = 1/3$ graded junction, $1/2$ abrupt junction
- v = applied voltage = $V_3 \sin \omega_3 t$
- V_3 = magnitude of pump voltage

Equation (8) can be expanded in a Fourier series when $v = V_3 \sin \omega_3 t$ to evaluate γ . Alternately, γ may be related to V_3 by expanding in a Taylor series about V_o as

$$C = C_{(v)} = C_{oB} + \sum_{\substack{n=1 \\ n_{odd}}}^{\infty} \frac{1}{n!} \frac{d^n C}{dV^n} \cdot (v - V_o)^n ; \tag{9}$$

$(v = V_o)$

so for $v = V_3 \sin \omega_3 t$ and $C(V)$ given by Equation (8), we may write

$$\gamma = \frac{C_1}{2C_o} = \frac{1}{2} \sum_{\substack{n=1 \\ n_{odd}}}^{\infty} \frac{(m+n-1)!}{(m-1)! (n-1)!} \left(\frac{V_3}{V_o} \right)^n \tag{10}$$

To relate changes in gain to changes in pump power, we may utilize a differential definition:

$$\frac{\Delta G}{G_o} \frac{P_o}{\Delta P} = \frac{P_o}{G_o} \frac{dG}{dP} = \frac{P_o}{G_o} \frac{dG}{d\gamma} \frac{d\gamma}{dV_3} \frac{dV_3}{dP} \tag{11}$$

We must now compute $d\gamma/dV_3$, which is

$$V_o \frac{d\gamma}{dV_3} = \frac{1}{2} \sum_{\substack{n=1 \\ n_{odd}}}^{\infty} \frac{(m+n-1)!}{(m-1)! (n-1)!} \left(\frac{V_3}{V_o} \right)^{n-1} \tag{12}$$

Referring back to the definition for α , we may write the gain expression to show γ explicitly as

$$G = \left[\frac{1 + \frac{\sqrt{G_o} - 1}{\sqrt{G_o} + 1} \frac{\gamma^2}{\gamma_o^2}}{1 - \frac{\sqrt{G_o} - 1}{\sqrt{G_o} + 1} \frac{\gamma^2}{\gamma_o^2}} \right]^2 ; \tag{13}$$

sc

$$\begin{aligned} \frac{\Delta G}{G_o} &= \frac{G_o - 1}{\sqrt{G_o}} \frac{V_3}{\gamma_o} \frac{d\gamma}{dV_3} \frac{\Delta P}{P_o} \\ &= \frac{G_o - 1}{\sqrt{G_o}} \epsilon \frac{\Delta P}{P_o} \end{aligned}$$

Now, $\epsilon = V_3 d\gamma/V_o dV_3$ is typically a factor of 2.0 and $V_3/V_o \approx 0.85$.

The gain could be expressed in terms of ϵ and the pump power as

$$G = \left[\frac{1 + \frac{\sqrt{G_o} - 1}{\sqrt{G_o} + 1} \left(1 + \epsilon \frac{\Delta P}{P_o} \right)}{1 - \frac{\sqrt{G_o} - 1}{\sqrt{G_o} + 1} \left(1 + \epsilon \frac{\Delta P}{P_o} \right)} \right]^2 \tag{14}$$

In Figure 3, we have an experimental plot of gain versus pump power in which the following is assumed:

- $V_3/V_o = 0.85$
- $G_o = 5.62 = 15$ db gain
- $m = 1/2$
- $\epsilon = 2$, computed.

It may be seen that the theoretical curve follows the experimental points fairly closely for deviations to high gains. The discrepancy is probably due to two things: (1) the detuning effect, since the idler susceptance is proportional to γ^2 , and (2) the nonlinearity in the pump circuit.

It is evident that it is desirable to rigidly control the

pump power variations. In addition, if the pump circuit is a high-Q circuit, any slight shift in the pump frequency will result in a change in pump power across the diode. It is therefore desirable to use as low a Q pump circuit as possible. By operating with a smaller voltage drive, V , the multiplying effect of ϵ can be considerably reduced.

however, this also reduces the γ and deteriorates the noise figure somewhat.

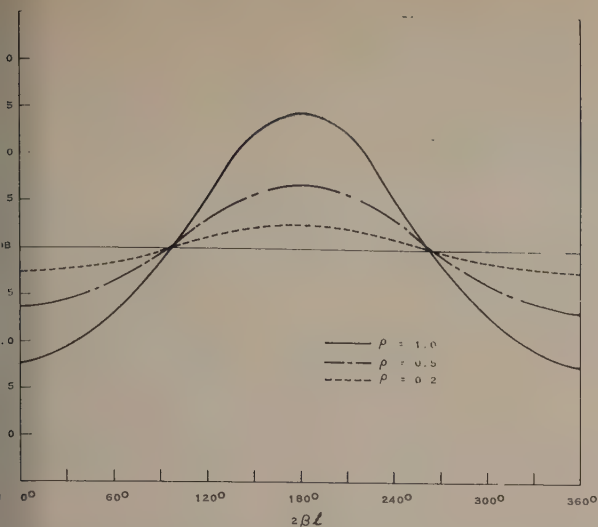


Figure 2—Mismatch phase shift vs. gain at 16-dB gain, 26-dB isolation.

It was also considered to operate the diode so that as the pump voltage began to saturate the diode it would draw current. This considerably reduced the effect of pump power changes. However, the gain was found to drift and center somewhat.

Temperature Stability

Temperature changes affect diode series resistance and junction capacitance. Usually the change in r_s will vary for different types of diodes. However, once a diode has been evaluated as a function of temperature, the information can be used to determine the performance of an amplifier. Then, too, in general, limits can be determined for any diode from theory. Changes in capacitance will affect both the gain and the center frequency of an amplifier. In some cases the detuning is quite severe. We shall concern ourselves with the change in resonance gain and the detuning from resonance.

As for resonance gain, only α will change as affected by r_s and r_s . Equation (2) can now be expressed as

$$G = \left(\frac{1 + \alpha}{1 - \alpha} \right)^2$$

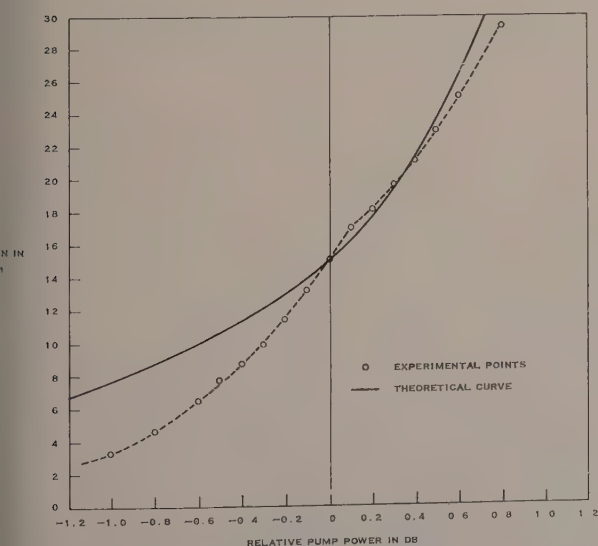


Figure 3—Gain vs. pump power normalized to 15-dB gain.

December, 1961

where

$$\alpha = \frac{\sqrt{G_0} - 1}{\sqrt{G_0} + 1} \cdot \frac{1}{\left(1 + \frac{\Delta r_s}{r_s}\right) \left(1 + \frac{\Delta C}{C_0}\right)^2}; \quad (16)$$

or, in terms of small differential changes,

$$\frac{\Delta G}{G_0} = - \frac{G_0 - 1}{\sqrt{G_0}} \frac{\Delta r_s}{r_s}, \quad (17)$$

$$\frac{\Delta G}{G_0} = - \frac{2(G_0 - 1)}{\sqrt{G_0}} \frac{\Delta C}{C_0}. \quad (18)$$

Let us consider the effect of the resistance first. An experimental curve of r_s versus T for a GaAs varactor is shown in Figure 4. In general, it may be said that the temperature variation in resistance is due to the variation in mobility, μ . Thus,

$$r_s = \frac{\text{CONSTANT}}{\mu};$$

so

$$\frac{1}{\mu} \frac{d\mu}{dT} = - \frac{1}{r_s} \frac{dr_s}{dT}. \quad (19)$$

The mobility temperature variation is due to three types of scattering:^{4,5} lattice vibration, which gives a $T^{-1.64}$ variation; ionic, which gives $T^{3/2}$ variation; and neutral, which provides a direct proportionality to temperature. For highly doped gallium arsenide, the temperature variation as seen from Figure 4 is almost flat near room temperature because of the interchange between the types of scattering mechanisms.

Over a small temperature range, the mobility is approximately a function of some power, q of T . The limits in q can be shown from the above considerations to be

$$-1.64 < q < 1.5$$

In terms of q ,

$$\frac{\Delta G}{G_0} = q \frac{G_0 - 1}{\sqrt{G_0}} \frac{\Delta T}{T_0}. \quad (20)$$

Thus it is desirable to use a diode that has a q as small as possible near room temperature. (Usually q can only be determined experimentally.)

In the case of the capacitance variation with temperature, the variation exists primarily because of the change in contact potential, V_D , with temperature. The temperature variation of contact potential has been discussed by Shockley and others.^{6,7} This is given as

$$V_D = \frac{E_{GAP}}{q} - \frac{kT}{q} \ln a T^3, \quad (21)$$

where

$$a = \frac{4 \left(\frac{2\pi k}{h^2} \right)^3 m_n^{3/2} m_p^{3/2}}{n_n p_p}. \quad (22)$$

Since the E_{GAP}/q term in Equation (21) is somewhat larger than the following term the differential change in contact potential may be written

$$\frac{T}{V_D} \frac{dV_D}{dT} = p. \quad (23)$$

Then, the percentage change in capacitance with temperature can be written

$$\frac{T}{C} \frac{dC}{dT} = p \frac{V_D}{C} \frac{dC}{dV_D} \tag{24}$$

The capacitance is related to contact potential as

$$C = \frac{\text{CONSTANT}}{(V_D - V_B)^m} \tag{25}$$

where V_B is the bias voltage and m is 1/2 for an abrupt junction and 1/3 for a graded junction. The percentage change in capacitance may now be computed as

$$\frac{\Delta C}{C_0} = \frac{-mp}{\left(1 - \frac{V_B}{V_D}\right)} \frac{\Delta T}{T_0} \tag{26}$$

Note that if V_B is reversed-biased such that $|V_B| \ll V_D$, the effect of temperature is drastically reduced. This has been verified by experiment. The curve of Figure 5 shows the variation in capacitance with T as a function of bias for a forward-bias GaAs tunnel diode. In this case, the exponent of p , near room temperature, is about 0.20. Because of the additional factor, $2mp/(1 - V_B/V_D)$, in comparing the resistance and capacitance effects it appears that the resistance temperature effect will be somewhat greater than the capacitance effect. However, the frequency shift introduced by the changing of C is worthy of note, since for narrowband amplifiers, this will give rise to larger gain variations at the center frequency than changes in r_s .

The amplifier resonance frequency is proportional to the inverse one-half power of the capacitance. The new reso-

nant frequency, ω_R , is given as

$$\omega_R = \omega_0 \left(\frac{C}{C_0} \right)^{-1/2} \tag{27}$$

the relative frequency shift is

$$\frac{\Delta \omega}{\omega_0} = - \frac{1}{2} \frac{\Delta C}{C_0} \tag{28}$$

or, in terms of T ,

$$\frac{\Delta \omega}{\omega_0} = - \frac{1}{2} \frac{mp}{\left(1 - \frac{V_B}{V_D}\right)} \frac{\Delta T}{T_0} \tag{29}$$

As an example, consider a change from 293°K to 243°K with $p=0.20$, $m=0.50$, $V=1.3$, $V_D=1.3$. This corresponds to a frequency shift of 0.46 percent, which is 13 Mc at a signal frequency of 2.9 kMc, which, in view of experimental data, is very reasonable.

The effect of C may be minimized by reverse biasing the diode as much as possible or by using a second diode to alter the bias as the temperature changes, thereby holding C constant.

Composite Amplifier Stability

To compute the composite stability for very small changes in all parameters, it is adequate merely to add the percentage variations. However, in most cases, since the gain is involved, these parameters must be considered compositely to determine exactly the amplifier performance.

The composite gain variation may now be written as

$$G(T, P, \rho, G_0, 2\beta l) = \frac{\left[1 + \frac{\sqrt{G_0} - 1}{\sqrt{G_0} + 1} \cdot \frac{1 + \epsilon \frac{\Delta P}{P_0}}{\left(1 + q \frac{\Delta T}{T_0}\right) \left(1 + p \frac{\Delta T}{T_0}\right)^2} + \frac{\rho \cos 2\beta l}{\sqrt{I}} \right]^2 + \frac{\rho^2 \sin^2 2\beta l}{I}}{\left[1 - \frac{\sqrt{G_0} - 1}{\sqrt{G_0} + 1} \cdot \frac{1 + \epsilon \frac{\Delta P}{P_0}}{\left(1 + q \frac{\Delta T}{T_0}\right) \left(1 + p \frac{\Delta T}{T_0}\right)^2} + \frac{\rho \cos 2\beta l}{\sqrt{I}} \right]^2 + \frac{\rho^2 \sin^2 2\beta l}{I}} \tag{30}$$

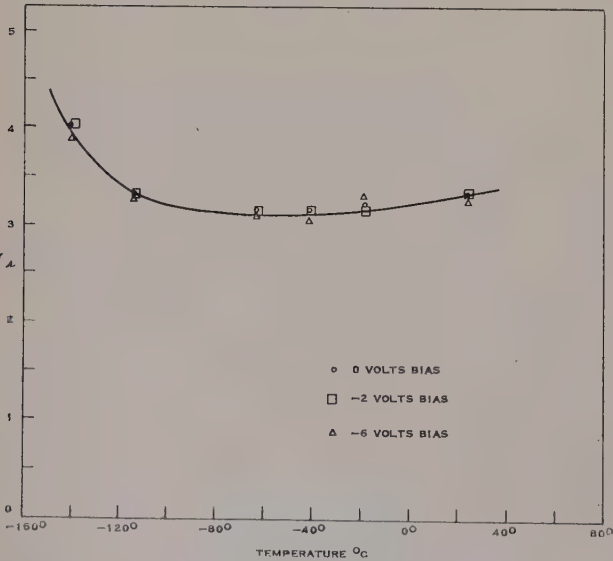


Figure 4—Variation of r_s with T for a GaAs varactor.

Equation (30) can be considerably simplified since the numerator is negligible in comparison with the denominator

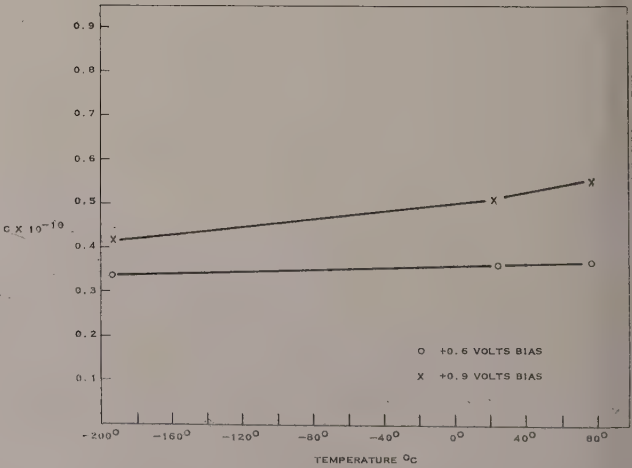


Figure 5—Variation of C with T for a GaAs varactor.

tor. In addition, since we are primarily concerned with the worst case, $2\beta l = \pi$,

$$\frac{G(T, P, G_0, \rho)}{G_0} = \frac{4}{(\sqrt{G_0} + 1)^2} \left[1 - \frac{\sqrt{G_0} - 1}{\sqrt{G_0} + 1} \left(\frac{1 + \epsilon \frac{\Delta P}{P_0}}{1 + q \frac{\Delta T}{T_0}} \right) \left(\frac{1 + p \frac{\Delta T}{T_0}}{1 + \frac{\rho}{\sqrt{I}}} \right) \right]^2 \quad (31)$$

Let us consider a typical case where

$$\begin{aligned} G_0 &= 50 \text{ (17 db)} \\ I &= 200 \text{ (23 db)} \\ \rho &= 1 \text{ (short circuit due to TR tube)} \\ \Delta P/P_0 &= 0.01 \\ q &= +0.16 \text{ (from Figure 4 at room temperature)} \\ p &= +0.20 \text{ (from Figure 5 at room temperature)} \\ T &= +25^\circ\text{C to } -40^\circ\text{C} \\ \epsilon &= 2, \end{aligned}$$

which is a 562 percent increase in gain, or 24.5 db, instead of 17 db.

$$Y_i = j\omega C_0 - \frac{\omega(\omega_3 - \omega)C_0^2\gamma^2}{\frac{r_s}{(\omega_3 - \omega)^2 L^2} - j\left[(\omega_3 - \omega)C_0 - \frac{1}{(\omega_3 - \omega)L}\right]} \quad (A-3)$$

Conclusions

Stable parametric amplifiers can be constructed by using good circulators, adequate compensating techniques, and stable pump power sources; by reverse-biasing the diode as much as possible; and by selection of a diode with a small resistance temperature slope.

In many applications, such as radiometers, temperature is not a problem, since the amplifier can be held at a constant temperature. Also, mismatch changes can be minimized in some systems by controlling the phase of the mismatch or by reducing existing mismatches.

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APPENDIX

In this appendix we shall briefly analyze the circuit of Figure 1 to define the important stability parameters, see the assumptions made, and derive the expression for the input impedance to the amplifier.

It will be assumed that the reader is acquainted with the original derivation of Heffner and Wade.¹

The magnitude of the currents flowing out of the diode at ω_1 and ω_2 may be written

$$\begin{aligned} I_1 &= j\omega C_0 V_1 + j\omega C_0 \gamma V_2 e^{j\phi_3} \\ I_2 &= j(\omega_3 - \omega) C_0 V_2 \\ &\quad + j(\omega_3 - \omega) C_0 \gamma V_1 e^{j\phi_3} \end{aligned} \quad (A-1)$$

The current around the idler loop may now be written

$$\begin{aligned} 0 &= I_2 = j(\omega_3 - \omega) C_0 \\ &\quad + j(\omega_3 - \omega) C_0 \gamma V_1 e^{j\phi_3} + \frac{V_2}{r_s + j(\omega_3 - \omega)L} \end{aligned} \quad (A-2)$$

To determine now the current flowing at ω_1 due to the idler current, we solve for V_1^*/V_2 and insert in the equation for I_1 .

If we assume that $[(\omega_3 - \omega)L]^2 \gg r_s^2$, we can write for the input admittance, Y_i , to the diode

Since the idler is near the self-resonant frequency of the diode, it will be assumed that

$$\frac{r_s}{(\omega_3 - \omega)^2 L^2} \approx (\omega_3 - \omega)^2 C_0^2 r_s \approx \omega_2^2 C_0^2 r_s.$$

The input impedance, Z_{IN} , is then given as

$$Z_{IN} = \frac{1}{Y_i} + r_s + j\omega(L + L'). \quad (A-4)$$

Solving, we obtain

$$\begin{aligned} Z_{IN} &= \frac{-\gamma^2 Q_{D1}^2 \frac{\omega_1}{\omega_2} r_s}{[1 - jQ_{D2} \delta_2]} - \frac{j}{\omega C_0} \\ &\quad + r_s + j\omega(L + L') \end{aligned} \quad (A-5)$$

where

$$\delta_2 = \left[\frac{\omega_3 - \omega}{\omega_2} - \frac{\omega_2}{\omega_3 - \omega} \right].$$

In most cases, except for very large γ and large Q_{D2} , $(\gamma^4 Q_{D2}^2) \ll 1$ and thus may be neglected. However, this assumption does make it desirable to use a lower $-\gamma$ diode with a high Q , rather than vice versa. The input impedance, with this assumption, then is that given in Equation (2) of the main text.

A COMPACT TUNABLE TUNNEL DIODE S-BAND RECEIVER*

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Introduction

Tunnel—or Esaki diodes appeared commercially about two years ago. The diode characteristics, negative resistance, small size, low power requirements, etc., immediately attracted a lot of attention, and since then the state of the art has been improved greatly. A number of papers describing diode characteristics and circuit techniques have been published. Furthermore, the diode manufacturers have improved their products immensely and lowered the prices of all production models.

Diodes with cutoff frequencies in the X-band and above have been on the market for several months. The S-band tunnel diode circuits were designed for the Sylvania D41C8, 8 and 10 kMc diodes.

It is the object of this paper to discuss some of the recent experimental results, and, in particular, to describe an S-band superheterodyne receiver employing two tunnel diode circuits, a preamplifier and a self-oscillating down-converter.

General Description of S-Band Receiver

Figure 1 shows a block diagram of the receiver. The components shown are: a high gain antenna horn, a broadband stabilizing network, a circulator with preamplifier, an isolator and a down-converter, next an IF amplifier and finally a detector and indicator.

The characteristics of the receiver are as follows: It is mechanically tunable with a single knob connected to

the down-converter; i.e., there are no tracking problems. The preamplifier has a nominal 17 db gain from 2.6 to 3.2 kMc. The noise figure of the receiver measured at the input terminal of the stabilizing network is less than 7 db over the 600-Mc band.

These characteristics, taken alone, are not unusual for S-band amplifiers. The 7-db noise figure can be achieved by using a good TWT preamplifier, and it can be improved a couple of db's with a parametric amplifier. The advantages of the tunnel diode circuits first become apparent when their size and power requirements are considered. Then they are immediately obvious. The size of the amplifier and the down-converter is about one cubic inch each, as will be shown. The power requirements are minimal, a 60 cent 1.3 volt mercury cell can operate each of the tunnel diode circuits continuously for about 100 hours. It is this combination of good performance characteristics, small size and low-power requirements that will revolutionize receiving systems at the microwave frequencies (as the transistor has done in the low-frequency field).

The components will next be described separately and in more detail.

Tunnel Diode Preamplifier

The stabilizing network and the preamplifier are mounted directly on the antenna horn to minimize trans-

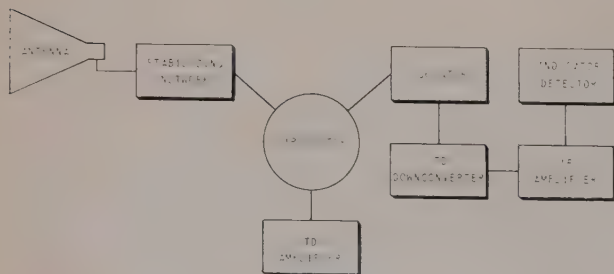


Figure 1 — Receiver block diagram.

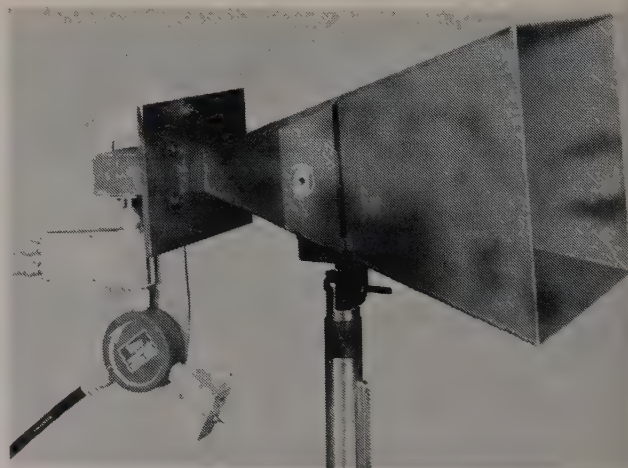


Figure 2 — Antenna horn with amplifier.

*This work was carried out under Signal Corps Contract DA 36-039 SC-87475.

**Now employed at Ryan Electronics, San Diego, California.

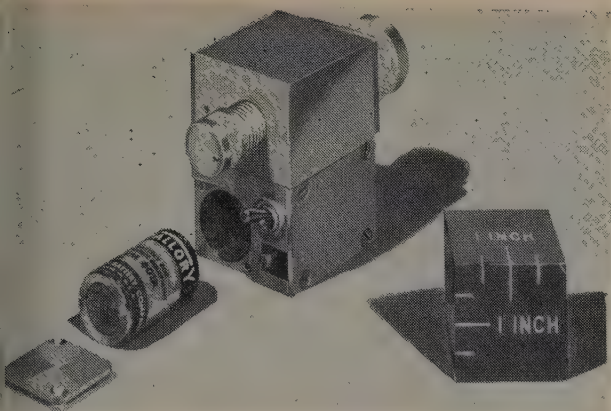


Figure 3 — One port amplifier.

mission loss to the amplifier. Figure 2 shows a photograph of the antenna with stabilizing network and amplifier. The amplifier is shown in detail in Figure 3. It is packaged to minimize size and weight. The top half of the amplifier, the bottom half is the battery supply containing a mercury cell, an on-off switch and an adjustable potentiometer for control of tunnel diode bias.

The amplifier circuit is shown in Figure 4. It has been analyzed and described by Gartner¹. The circuit was chosen for its simplicity. The diode is part of a single tuned tank circuit, it is represented by the terminal resistance and capacitance. The load resistance is in parallel with the diode and the external inductance L .

The diode terminal capacitance, C_D , and terminal negative resistance, R_D , are very frequency sensitive near the cutoff frequencies of the diode. They can, however, be assumed constants from DC to about one-third of the diode cutoff frequencies. L is a short piece of grounded transmission line. The cross-sectional view shows how the inductance is variable by adjustment of a length of shorted line. The total line length between the diode and short is typically from 1/8th to 1/2 inch. C is a feed-through bypass capacitor made of a ceramic material with high dielectric constant.

The external inductance of the capacitor is so small that it can be neglected. Resistor, R_2 , has a value less than the magnitude of the negative resistance in order to stabilize the amplifier at dc. Diode bias is adjusted with resistor R_1 . L is adjusted to resonate with the diode capacitance at the desired frequency. Transducer gain at resonance is shown in Figure 5 as a function of ratio

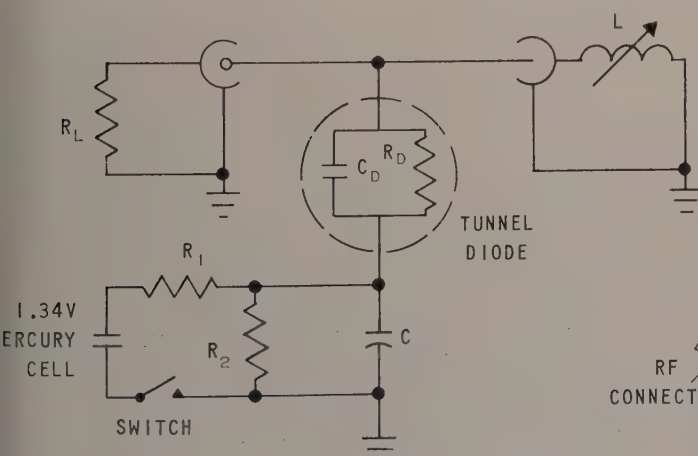


Figure 4 — Amplifier circuit and cross-sectional view.

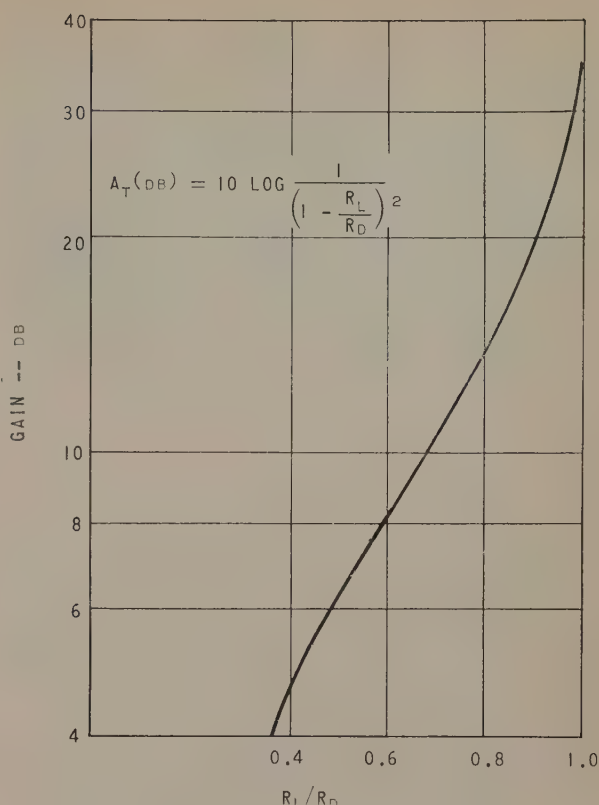


Figure 5 — Transducer gain.

R_L/R_D . Here, R_L is the input and output resistance of the amplifier. If R_L exceeds R_D the circuit will oscillate at the resonant frequency. To obtain a constant high gain over a large tunable frequency range, all efforts are taken to maintain a constant ratio of R_L/R_D :

1. The input transmission line is coupled directly to the diode circuit, and
2. Impedance transforming line sections are eliminated by selecting diodes with negative resistance values equal to, or near, 55 ohms.

The center frequency of a typical amplifier is adjustable over 1 kMc or better. Maximum frequency of operation depends on the diode capacitance and the minimum inductance of the shorted line. Amplifiers have been built with stable gain of greater than 20 db up to 3.9 kMc. The linear dynamic range is from about -95 dbm to -40 dbm. The diode is saturated at -20 dbm.

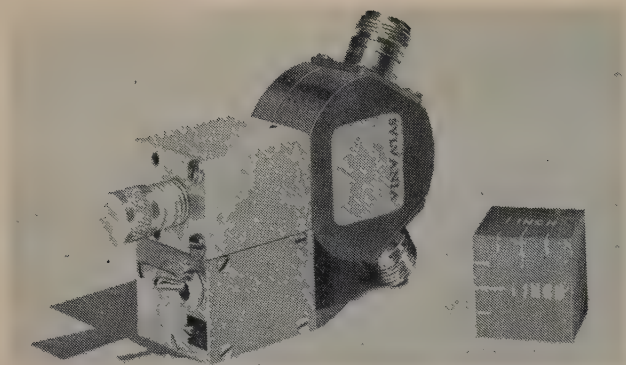


Figure 6 — Broadband tunnel diode amplifier.

Circulator

The reflected and amplified wave is separated from the incoming wave with a circulator. The bandwidth of the circulator is the limiting factor in design of broadband S-band amplifiers. The voltage gain-bandwidth product of the best broadbanded amplifiers run up to 6 kMc; i.e., amplifiers with transducer gain of 23 db have a 3-db bandwidth of over 400 Mc. The noise figure of the amplifier was measured at 6 db. A broadbanded amplifier is shown in Figure 6.

The transmission line length connecting the circulator and the amplifier is optimized such that the inherent frequency characteristics of the circulator are utilized to broaden the amplifier bandwidth².

Stabilizing Network

If a circulator with amplifier is connected directly to an antenna horn with a standard coax-to-waveguide adaptor, the amplifier will be unstable and oscillate. The reason is that the transition to waveguide has a very high VSWR at frequencies below the waveguide cutoff frequency. It was, therefore, necessary to separate the horn and the circulator with a broadband stabilizing network.

The stabilizing network, also called a hybrid filter, is shown in Figure 7. It consists of a hybrid coupler connected to two matched low-pass filters terminated in 50-ohm loads. The filter cutoff frequency is 2.4 kMc.

The network was built using stripline techniques as shown in Figure 8. The hybrid is an electromagnetic quarter wavelength coupler of which only one of the coupling plates is seen. The other is printed on the other side of the 20-mill card. The other filter center conductor is also printed on the other side of the card.

The insertion loss of the network is less than 0.5 db from 2.6 to 4.0 kMc. With the input terminal connected to the antenna, VSWR of the output terminal is less than 1.5 at frequencies from dc to 3.5 kMc.

Isolator

After amplification, the signal is passed out to the third arm of the circulator and through an isolator. The isolator provides a good match for the amplifier and it isolates the down-converter oscillator from the antenna and the amplifier.

Down-Converter

The down-converter circuit diagram is shown in Figure 9. The circuit consists of an oscillating RF cavity and a stable IF tank circuit. The main difference between this circuit and the amplifier circuit is that the RF bypass

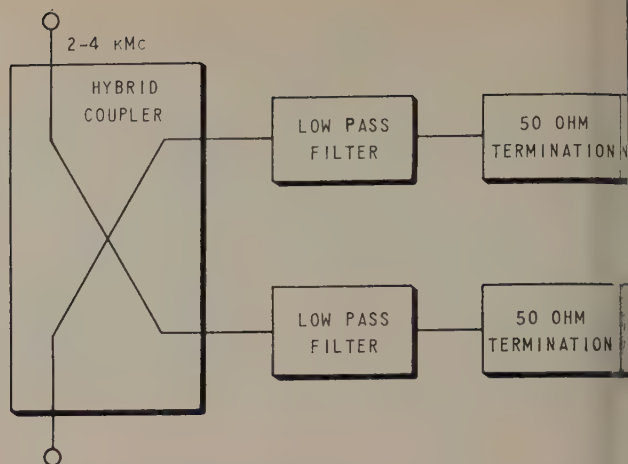


Figure 7 — Block diagram of stabilizing network.

capacitor is smaller. Here it is resonated with an inductor at the IF frequency. The diode capacitance resonates with the tunable inductor, L , at the signal frequency — the intermediate frequency. The requirement for oscillation at RF is that the negative diode resistance is smaller than the RF load resistance, R_0 . The power level of the oscillator is not significant in this application. The oscillator is typically tunable over a 1000-Mc range from 2.5 to 3.0 kMc. The upper limit is strictly a function of the diode capacity and the design of the external inductance. By decreasing the external inductance sufficiently, it is possible to operate the down-converter through the C-band. Receiver signals are applied directly across the oscillating diode circuit. By using a tunnel diode with a negative resistance of 35 to 40 ohms, it is possible to use direct coupling without transforming line section.

The advantage of direct coupling over loop coupling is that the load resistance can be determined accurately and that signal loss can be minimized. By avoiding transforming line sections the circuit can be built smaller and be capable of operation over a larger frequency range. A cutaway view of a down-converter is shown in Figure 10.

Noise figure of the down-converter is from 12 to 15 db depending on the RF loading and the IF match. Thus the tunnel diode down-converter provides performance comparable to that of a broadband crystal mixer.

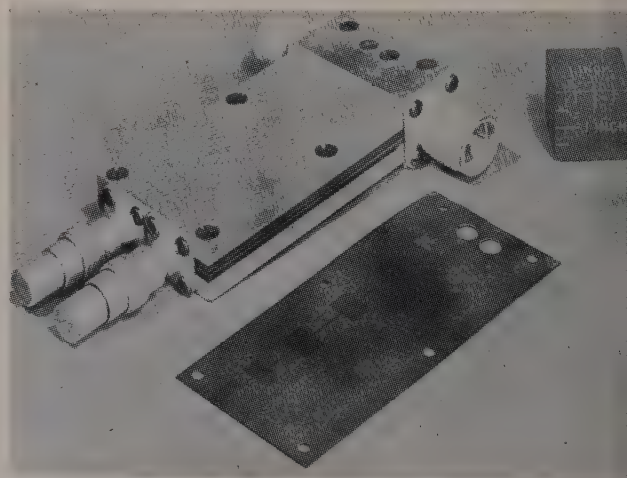


Figure 8 — Stripline stabilizing network.

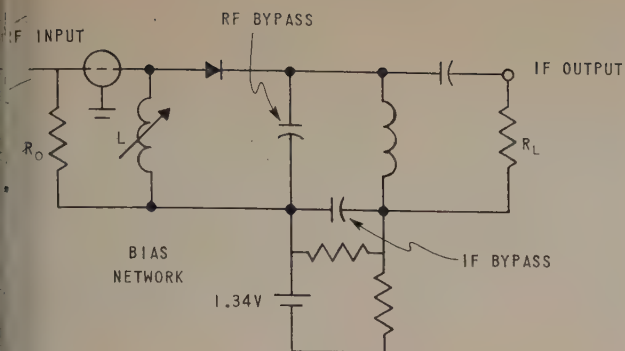


Figure 9 — Circuit diagram of down-converter.

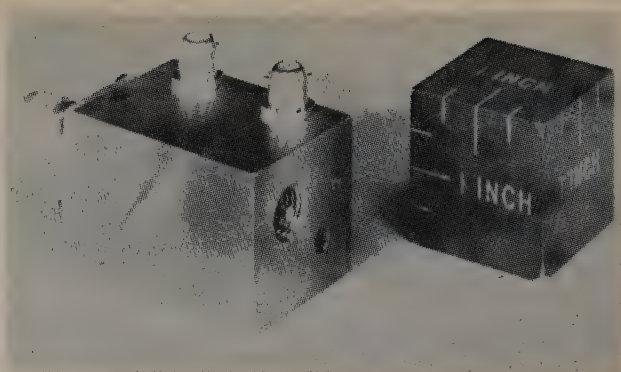


Figure 11 — Miniaturized down-converter.

Figure 11 shows a photograph of the miniaturized down-converter. Figure 12 shows the down-converter in a miniaturized solid-state receiver.

The receiver contains a 10-Mc IF amplifier, detector, video and audio amplifier. Battery, on-off switch and other controls are also seen on the photograph.

The receiver measures 2 x 4 x 1 inches. As shown here, the antenna can be mounted directly on the input connector to the converter. It is tunable from 2.0 to 3.0 kMc. Noise figure of the receiver without the preamplifier is about 15 db. The two outputs are audio and video. The battery, as shown, is included in the package, it can operate the receiver component about 12 hours continuously.

Temperature Stability

Several tests have been made to establish the stability of tunnel diodes in extreme environmental conditions. The static characteristic curves of several tunnel diode samples were measured as a function of temperature. One such set of curves is shown in Figure 13.

The minimum negative resistance was measured with an accuracy of better than 5 per cent. These measurements show that the negative resistance change less than 5 per cent with change of temperature from 20 to 85 degrees C. Other measurements verified this finding. The mid-band gain of an S-band amplifier varied gradually from 25 db at 24 degrees C to 22 db at 65 degrees C. This corresponds to a change of negative resistance of 2.5 per cent. In ohms, the change amounts to 0.03 ohms/degrees C.

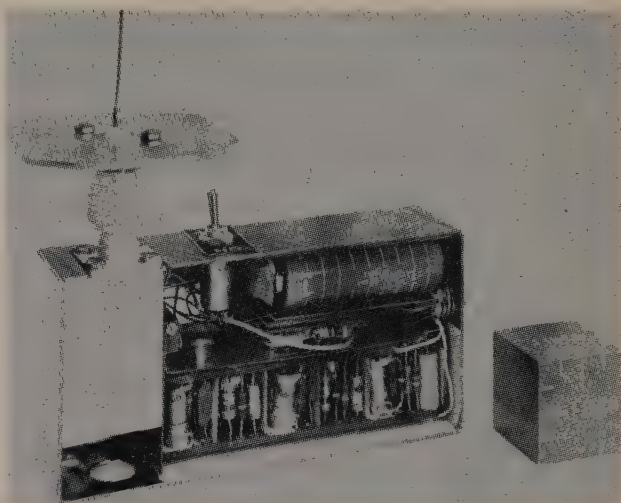


Figure 12 — Solid state S-band receiver.

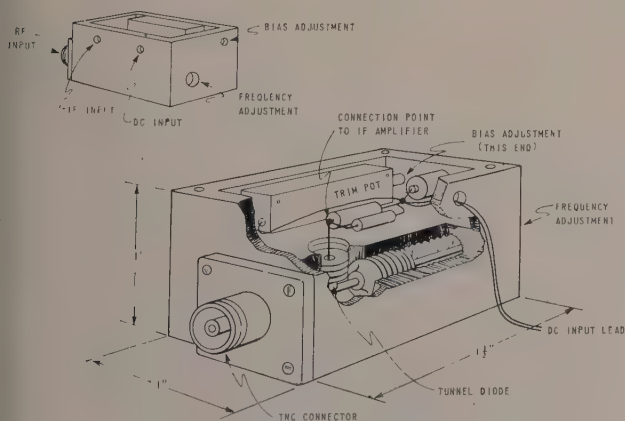


Figure 10 — Miniaturized tunnel diode down-converter.

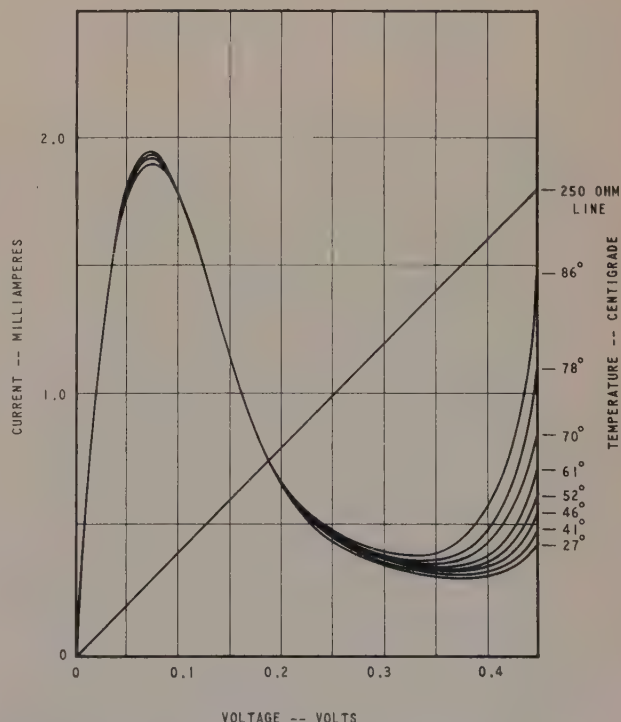


Figure 13 — Temperature characteristics of Sylvania D 4115 A tunnel diode.

The frequency stability of an S-band down-converter oscillating at 2840 Mc was measured as 0.05 Mc/degrees C over the temperature change of 25 to 65 degrees C.

Summary

In conclusion it can be stated, without reservation, that tunnel diode devices are already taking a firm position among microwave components. It is anybody's guess how much the diode will be used — say two years, or five years, from now. From the progress that has been made in the last two years it appears that the tunnel diode will

be replacing the microwave mixer diodes and vacuum tube oscillators in many receiving systems and, in addition, will be useful as preamplifiers in lightweight systems where noise figure requirements are no more demanding than those met by low-noise TWT's.

The frequency coverage capabilities of tunnel diodes are presently limited by the ferrite circulators and cannot match the present octave-bandwidth capability of low-noise TWT's. However, it seems reasonable to expect that continued improvements of ferrite devices and of tunnel diode circuits will bring the bandwidth capabilities up to par.

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A WIDE BAND CONICAL SCAN ANTENNA FEED SYSTEM

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I. Introduction

As part of its research program in electromagnetic propagation, the Signal Corps has always stressed the value of data received from a systematic study of signals coming from satellites. Many of the recent satellites carry a number of beacons or transmitters, and a tracking installation not only has the task of passively tracking the satellite beacon for orbital information but also has to monitor all satellite transmissions for telemetering and other data. Last minute changes of transmitter frequencies are not unusual. To accommodate all possible frequency channels, a large number of narrow band feeds would be necessary so that a very wide band feed would be an extremely useful device. Also, when tracking unknown satellites, no prior information is available so that the antenna system should cover as much of the spectrum as possible.

The problem of wide band tracking systems has been apparent for some time. Eighteen months ago, work was started at Jasik Laboratories to investigate some of the techniques which might be useful for large paraboloidal antenna systems.* For the purposes of this program, "wide band" is defined as a frequency range of one or more octaves, and efforts were directed only toward those systems which appeared to offer the possibility of achieving this sort of frequency coverage.

Because of the large frequency coverage required, the antenna elements investigated were of the frequency-independent types¹ which included log-periodic antennas and log-spiral² antennas. One of the more promising systems which resulted was a conical-scan system using two log-spiral antennas which could be switched to receive either right-hand or left-hand circular polarization.

The system described in the following section has been

evaluated in a small paraboloid, and an operating system has been delivered for evaluation in a 28 foot paraboloid and in a 60 foot paraboloid. Although the experimental model operates efficiently over more than two octaves (900—4000 Mc), the configuration used can be designed to operate over a bandwidth of more than 10 to 1. Measurements have shown that in the operating bandwidth, the secondary scan pattern has an essentially constant crossover level with acceptable pattern and impedance performance.

II. A Dual-Spiral Conical-Scan Primary Feed

The radiating portion of a dual-spiral conical-scan primary feed is shown in the photograph in Figure 1. This

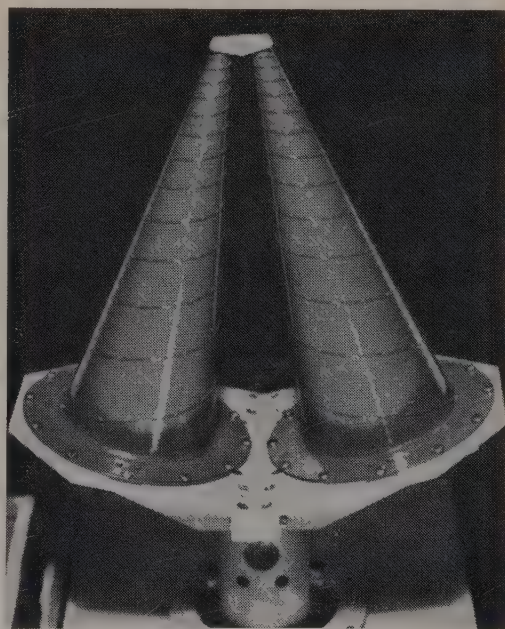


Figure 1 — Photograph of dual-spiral conical-scan feed.

*The work performed under this contract was made possible by the support of the Advanced Research Projects Agency under Order 57-59, through the U. S. Army Signal Research and Development Laboratory."

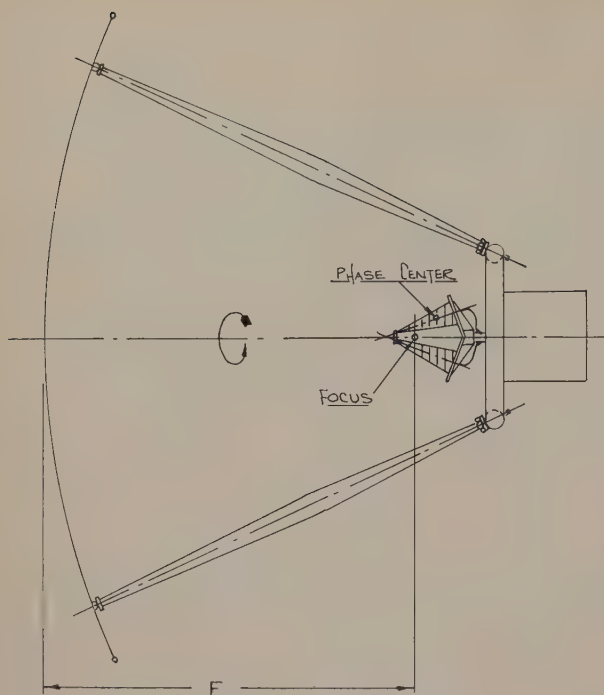


Figure 2 — Dual-spiral feed mounted in paraboloid.

feed employs a pair of balanced two-arm conical log-spiral** antennas which are identical except that the two antennas are wound to produce opposite senses of circular polarization. The two antennas are mounted in the paraboloid as shown in Figure 2 and are symmetrically disposed about the axis of rotation which coincides with the focal axis of the paraboloidal reflector.

The inherent advantages of the dual-spiral conical-scan feed configuration may be summarized as follows: (1) A conical scan is achieved by a simple rotation (as opposed to a nutation) of the feed about the focal axis since the conical log-spiral antennas produce circularly polarized radiation. (2) The dual-spiral feed configuration is inherently dynamically balanced since the mechanical properties of each of the two spiral antennas are essentially identical. (3) Polarization diversity is achieved by means of a simple switching operation. (4) The feed will track on any incident polarization since either of two orthogonal polarizations is available to the receiver. (5) Mutual coupling effects between the two conical log-spiral antennas are substantially reduced (but not completely eliminated) because of the fact that the two antennas are cross polarized.

a. Design Principles and Performance Trends

The geometry and parameters which define a conical log-spiral antenna are given in Figure 3. When the two arms of the antenna are fed against each other with a balanced feed, it produces an end fire beam along the axis of the cone which is circularly polarized throughout a radiation cone with a half-angle of approximately 80° . The sense of the circular polarization is determined by the winding sense.

A balanced two-arm conical log-spiral antenna is an inherently frequency-independent radiator. In principle,

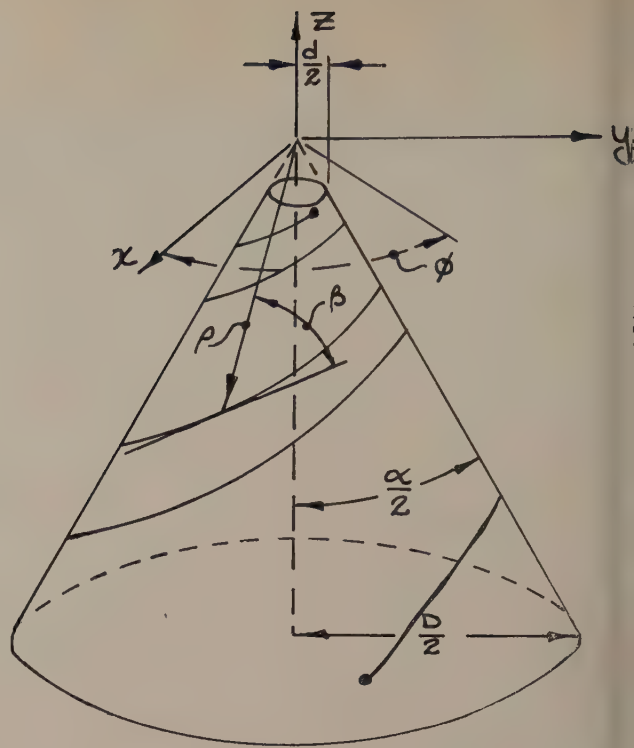


Figure 3 — A two-arm conical log-spiral antenna. Equations defining the two spiral arms are:

$$\rho_1 = e^{b\phi} \quad \rho_2 = \rho_1 e^{-b\pi} \quad b = \cot \beta \sin \frac{\alpha}{2}$$

the bandwidth achievable is a function only of the antenna dimensions. The low frequency limit of operation is approximately equal to the frequency at which the base diameter of the cone (D in Figure 3) is $\lambda/3$, and the high frequency limit of operation is approximately equal to the frequency at which the truncation diameter of the cone (d in Figure 3) is approximately equal to $\lambda/5$. In effect, therefore, the lower frequency limit of operation of a dual-spiral conical-scan feed is governed by its maximum size and the difficulty of the mechanical problems to be solved. The upper frequency limit is determined by the care taken in maintaining the fine detail in the region of the cone apex.

The radiation phase center of a balanced two-arm conical log-spiral antenna lies on the axis of the cone, at a point somewhat forward (towards the apex) of the intersection of the axis with that plane which cuts a wavelength circumference circle on the cone. The distance from the cone apex to the phase center is therefore directly proportional to the wavelength. It then follows that if a single conical log-spiral antenna is oriented with its apex on the focal axis of a paraboloid and is rotated about that axis, the secondary beam will perform a conical scan with a crossover level which is essentially independent of frequency. The crossover level is a function of the angle between the cone axis and the focal axis and remains constant with frequency because, as the secondary beam broadens at lower frequencies, the phase center of the feed is displaced transversely from the focal axis by a proportionate amount. For a paraboloid with focal length to diameter ratio of 0.425, the crossover level will be approximately 3 db down from the peak of the beam when this angle (the angle $\psi/2$ in Figure 4) is equal to the cone apex angle α .

** The abbreviation "log-spiral" will be used to imply the logarithmic (or equiangular) spiral.

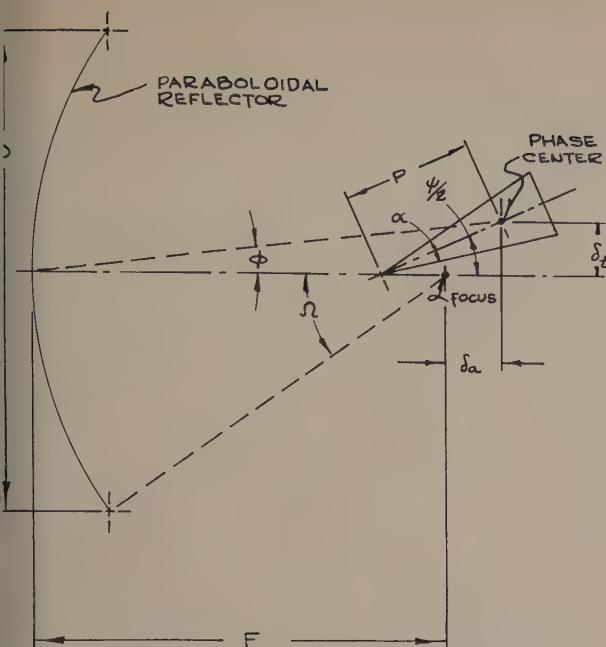


Figure 4—An offset conical log-spiral feed for a paraboloidal reflector.

The angle between the cone axis and the focal axis of the paraboloid may be adjusted to vary the crossover level within limits. For a dual-spiral conical-scan feed, the minimum crossover depth obtainable is determined by the increasing amount of mutual coupling as the two log-spiral antennas are moved closer together. The maximum crossover depth is limited by the increasing asymmetry of the reflector illumination as the angle between the cone axis and focal axis is increased. In practice, essentially frequency-independent crossover depths ranging from approximately 1 db to approximately 5 db are readily obtainable with the dual-spiral conical-scan feed configuration.

There are two problem areas associated with the use of the dual-spiral conical scan feed configuration. The first of these arises from the fact that, with a fixed axial position of the feed, the transverse offset of the phase center from the focal axis (δ_t in Figure 4) is accompanied by a displacement along the focal axis (δ_a in Figure 4). For crossover levels of the order of 3 db down (i.e., for secondary beam tilt angles of the order of a half beamwidth) there is virtually no loss in gain associated with the transverse phase center offset. On the other hand, the axial defocussing may give rise to a noticeable loss in gain. The precise value of the loss in gain is a function of the phase center offset (expressed in wavelengths) and the focal length to diameter ratio of the paraboloid. For $F/D=0.425$, an axial displacement of one-half wavelength will result in a loss in gain of approximately 0.9 db.

With a fixed position feed, minimum defocussing over a band of frequencies results when the feed is properly focussed at the midband frequency. The maximum defocussing at the ends of the band is then a function of the cone apex angle. The maximum defocussing increases with decreasing values of α .

A loss in gain is accompanied by a broadening of the secondary beam of the paraboloid. Thus, axial defocus-

sing will cause the crossover level to vary with frequency by a small amount. It is of interest to note, however, that the loss in gain at crossover is always less than the loss in gain for the peak of the beam.

Optimum performance of conical log-spiral antennas is obtained with values of α less than about 35° . It is evident that for a fixed position feed, α should be as large as possible in order to minimize the effects arising from the axial defocussing. On the other hand, smaller values of α are desirable in order to minimize the asymmetry of the paraboloid aperture illumination. In addition to these considerations, the choice of α will depend in some measure on the mechanical problems arising from the rotation requirement.

The second problem area associated with the use of a dual-spiral conical-scan feed configuration is one which is common to all circularly-polarized conical-scan systems in which the rotating (not nutating) primary feed is not perfectly circularly polarized. For this case, the on-axis polarization ellipse rotates with the feed so that when tracking a linearly polarized signal, the feed ellipticity will introduce a second harmonic of the fundamental scan frequency into the modulation envelope of the signal delivered to the output of the scanning feed. The effect of this second harmonic modulation on the performance of the tracking system will be minor provided that the tracking receiver has suitable filtering in its output circuits to eliminate all but the fundamental scan frequency.

The performance trends which govern the choice of the spiral rate may be summarized by the following observations. Tight spirals produce radiation patterns which are less frequency-dependent and which exhibit better circularity than those of loose spirals. The half-power beamwidths of tight spirals are less than those of loose spirals, although this trend does not continue indefinitely. For very tight spirals, the half-power beamwidth of a conical log-spiral antenna is generally of the order of 60° to 70° . Half-power beamwidths of this order are quite suitable for proper illumination of paraboloids with $F/D=0.425$. Therefore, the only reason to use a loose spiral would be to feed a short focal length paraboloid. A preference for the use of tight spirals is also indicated from the fact that the broader beams of the loose spiral antennas result in increased mutual coupling effects.

b. Description of the Feed and Summary of Performance

The dual-spiral conical-scan primary feed shown in Figure 1 employs two conical log-spiral antennas with the following parameters:

- | | |
|------------------------------|-------------------|
| (a) cone angle: | $\alpha=20^\circ$ |
| (b) spiral rate angle: | $\beta=73^\circ$ |
| (c) angle between cone axes: | $\psi=30^\circ$ |
| (d) base diameter: | $D=4.30''$ |
| (e) truncation diameter: | $d=0.54''$ |

The truncation and base diameters specified are the diameters at which the spiral arms begin and end and not the actual base and truncation diameters of the fiberglass cones.

The individual antennas were fabricated by winding copper wire on preformed polyester fiberglass cones. The antennas were fed by tapered coaxial baluns located inside the cones along the cone axes. In addition to providing the required balanced feed voltages, these baluns also served to transform the (approximately) 180 ohm

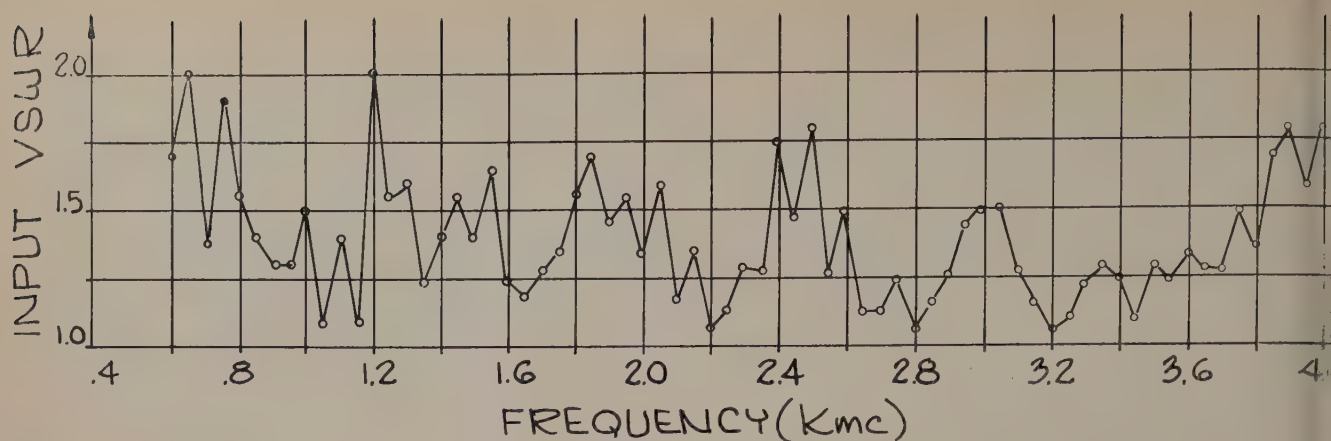


Figure 5 — Input VSWR of one of the two conical log-spiral antennas of the dual-spiral feed (measured through the rotary joint and polarization-selection coaxial switch).

impedance levels of the antennas down to the 50 ohm impedance level of the input lines.

The base and truncation diameters indicated above were chosen to achieve satisfactory frequency-independent operation in the 900 — 4000 Mc range. The input VSWR of one of the two antennas is shown in Figure 5. (This data includes the mismatches of the polarization-selection coaxial switch and of the rotary joint).

It is evident that the impedance performance in the frequency range 600 — 900 Mc is comparable with that in the design band. This result was achieved by terminating the spiral-antenna arms to their mounting flange through carbon resistors. Although no quantitative measurements of gain were taken, it is believed that there is a substantial loss in gain at frequencies below about 800

Mc, since the cone is operating below its nominal cutoff

An indication of the quality of the primary pattern performance of the feed is given in Figure 6. The data shown contrasts the on-axis ellipticity ratio (i.e., in the direction of the cone axis of the fed antenna) obtained with one element of the feed by itself and when used in the dual-spiral configuration. The effect of the coupling to the unfed antenna is to cause a substantial increase in the on-axis ellipticity ratio.

Although the antennas were designed for operation down to 900 Mc, resistive termination of the antenna arms results in acceptable circularity down to at least 600 Mc (i.e., the ellipticity ratios in the 600 — 900 Mc range are no higher than those in the 900 — 4000 Mc range).

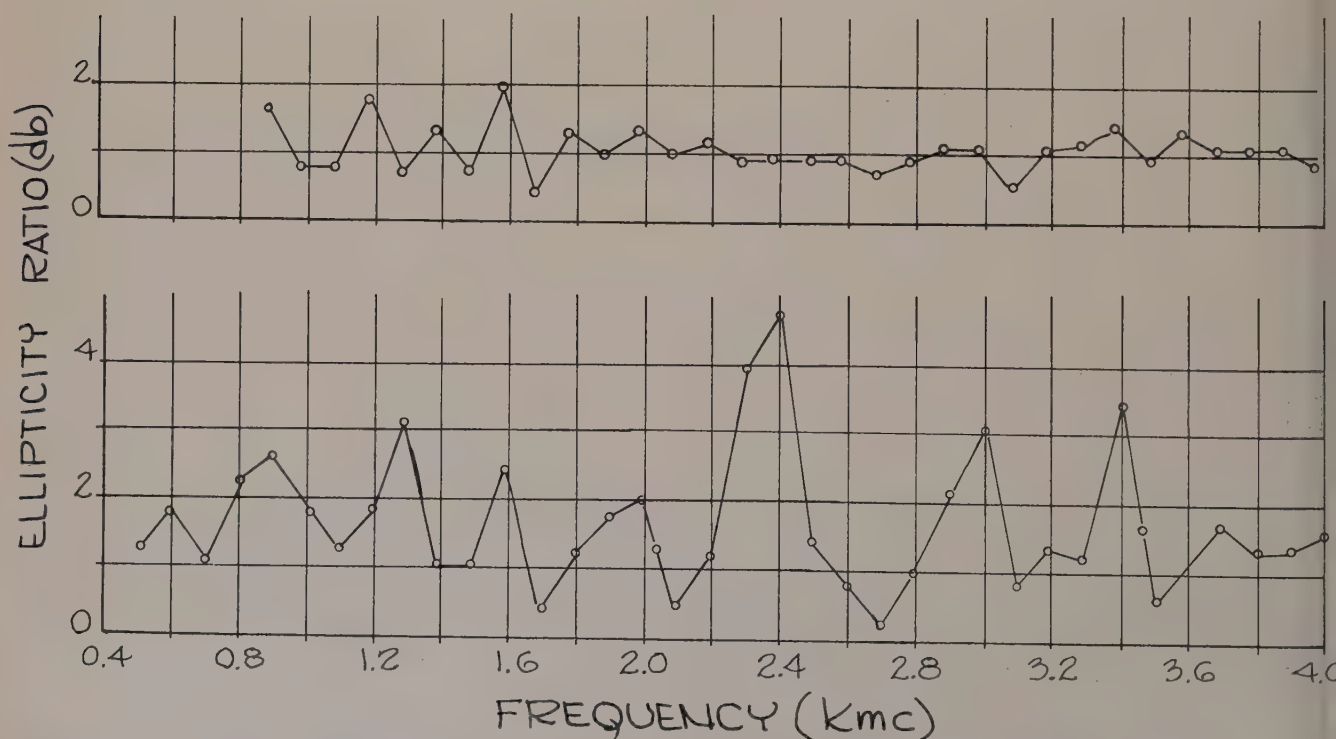
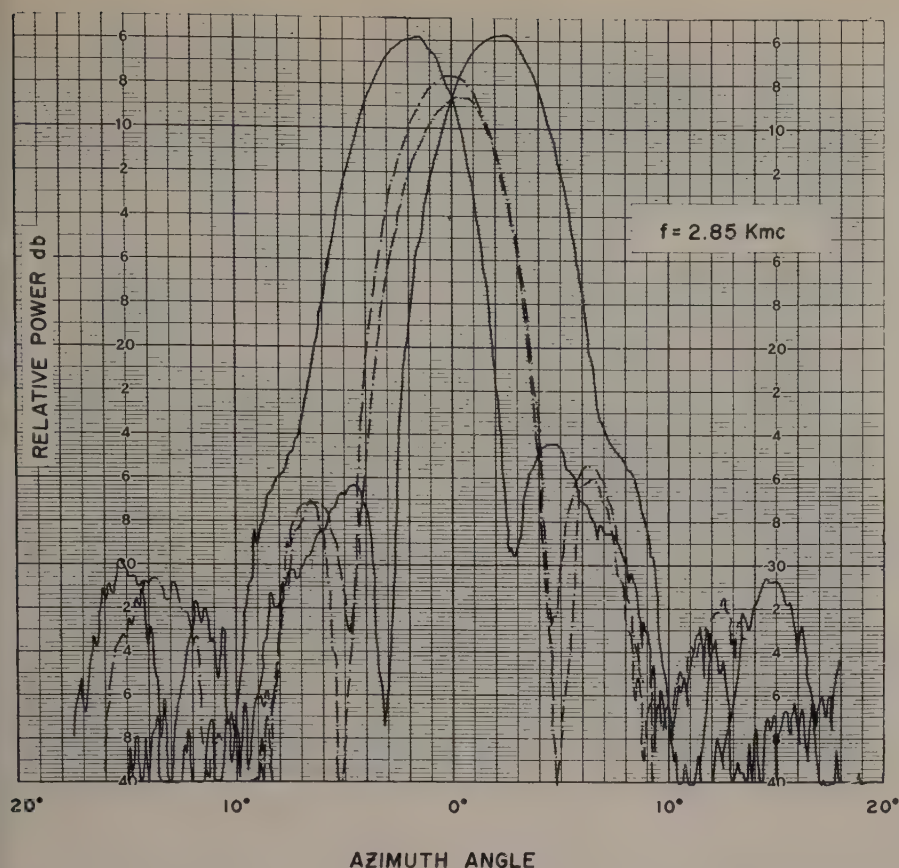


Figure 6 — Primary pattern ellipticity data for radiation in the direction of the cone-axis of the fed antenna. Upper curve: A single conical log-spiral antenna. Lower curve: The same antenna in a dual-spiral array.



SECONDARY PATTERNS
FOR FOUR CARDINAL
POSITIONS OF DUAL-SPIRAL
FEED NO. 61K

FREQUENCY 2.85 Kmc
FEED POSITION $d = 27''$
SOURCE ANTENNA
POLARIZATION
LEFT HAND CIRCULAR

Figure 7 — Secondary crossover patterns for four cardinal positions of the dual-spiral feed (circular polarized source antenna).

Figure 7 shows a typical set of secondary patterns obtained from a 2/3 scale model of the feed described above installed in a 65" diameter paraboloid with $F/D=0.425$. The four patterns shown were obtained with the feed antenna located in four cardinal positions, two in the vertical plane (the broken lines) and two in the horizontal plane. In taking these particular patterns, the source antenna was circularly polarized.

III. Conclusions

A conical-scan feed system has been developed which has acceptable performance over an extremely wide bandwidth. It is expected that this system will find extensive application to operational equipments. A photograph of an experimental feed system mounted in a 28 foot reflector is shown in Figure 8.

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Figure 8 — Feed System mounted in 28-foot tracking dish at Deal, N.J.

A VERY BROADBAND MICROWAVE ANTENNA COUPLER

K. A. STEELE

RADIO AND ELECTRICAL ENGINEERING DIVISION
NATIONAL RESEARCH COUNCIL OF CANADA

Ottawa • Canada

Introduction

The laboratory development, production line testing, and maintenance testing of a transmission system connected to an antenna can be simplified by the use of a reflectionless antenna probe or coupler. Low reflection couplers may be used for relative transmission measurements which would otherwise require costly and time-consuming work on an antenna range.

The reflectionless coupler does not supplant the antenna range for far-field pattern measurements but it may be employed instead of a range for relative transmission measurements on microwave systems. Testing is done on an antenna range either because the far-field must be probed to determine antenna radiation patterns or because sufficient isolation between the probe and antenna must be provided so that reflections do not affect conditions at the antenna or in its associated transmission system. When measurements of the far-field as such are not required, an antenna coupler which is made to be reflectionless with lumped attenuation can be placed very close to the antenna aperture and can be used instead of an antenna range in which the attenuation is provided by separation in space.

Applications

Routine laboratory tests can be done with a coupler on the work bench more quickly and conveniently than on an antenna range. Approximate relative gain measurements can be made on antennas under development. Such tests may be used to indicate the effect of small changes to an antenna or to make comparisons among antennas having nearly equal aperture sizes. However, comparisons are only strictly valid between systems whose antennas have identical near-fields. Comparative loss measurements can also be made for testing the effects of changes made in components such as adapters, filters or detector mounts connected to the antenna.

The antenna and coupler need be only a foot or so above the work bench and may be fairly close to other

reflecting objects. This is made possible by designing the coupler so that its radiation pattern is not too broad and also so that the coupler aperture effectively shadows the near-field zone of the antenna under test. This minimizes the possibility of reflections from objects near the coupler-antenna site.

Since an antenna range is usually located on a roof or in an anechoic room, much time may be taken in making minor adjustments and in making step-by-step changes in components or settings to achieve the desired results. An outdoor range has additional problems due to wind, rain and snow. Interference may also be very difficult to overcome on an antenna range, especially when tests are done over a wide frequency band. Couplers have been used to advantage in such cases.

Outside the laboratory, a reflectionless antenna coupler is a convenient device for many applications in maintenance testing and production line testing. Coupling to a transmission system terminated in an antenna can be accomplished without disturbing the existing impedance conditions. This may be particularly useful in checking operational equipment in place. In production line testing of many identical assemblies, comparative measurements of transmission loss against a standard system may be done quite simply without the space requirement or high cost of an antenna range.

Interference testing is another field in which a reflectionless probe is useful. It is generally difficult to find

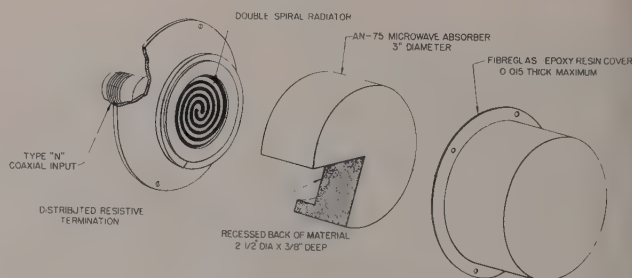


Figure 1 — Antenna coupler with spiral radiator.

the microwave journal

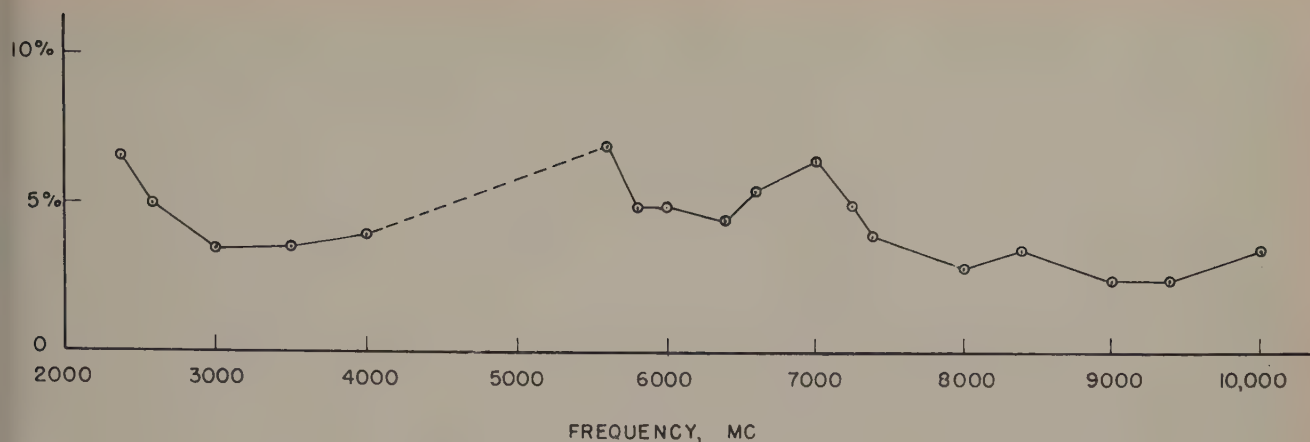


Figure 2a — Aperture reflection coefficient.

the exact location of an r.f. leak in waveguide joints or equipment cases if the probe being used causes reflections. There is little or no correlation between the position of the probe and the source of radiation when reflections are present. Experience has shown that a reflectionless coupler is well suited for this type of work.

Antenna couplers have been made^{1,2} with good performance over octave bandwidths in the frequency range 1 kMc/s to 20 kMc/s. The coupler described in this paper may be used over a bandwidth greater than two octaves; from 2 kMc/s to 10 kMc/s. The extremely broadband performance is obtained by using a spiral antenna as the radiator.

It should be noted that this coupler and those described in References 1 and 2 were designed for low power applications such as testing receiving systems. Related devices are available^{3,4,5} which will absorb considerably higher powers. These couplers or caps were designed primarily for testing active equipment on aircraft.

Construction

Construction details of the antenna coupler are shown in Figure 1. The radiator⁶ is a double spiral photo-etched on 1/16 inch epoxy fiberglass laminate with 0.0015 inch copper. A distributed absorber made of epoxy resin and powdered iron provides a resistive termination for the outer ends of the spiral. One spiral is connected to the inner conductor and the other to the outer conductor of a 50-ohm coaxial line terminated in a type-N connector. A piece of broadband microwave absorbing material*

is located directly in front of the spiral to reduce the reflection from the coupler aperture. Some material is removed from the centre of the piece of absorber to lower the transmission loss, especially at X-band. A molded fibreglas cloth-epoxy resin cover over the absorbing material protects the absorber from physical damage and is also a moisture barrier. The reflection coefficient of the absorber increases considerably if it is allowed to absorb moisture.

Performance

Reflection coefficient, transmission loss and radiation pattern are important electrical parameters of a coupler. The most important of these is the average coupler aperture reflection coefficient, Γ_c . This is measured in terms of the maximum change in VSWR of an antenna when the coupler is moved back and forth directly in front of it. Thus, Γ_c is

$$\Gamma_c = \frac{\left[\frac{\max \text{ VSWR }}{\min \text{ VSWR }} \right]^{1/2} - 1}{\left[\frac{\max \text{ VSWR }}{\min \text{ VSWR }} \right]^{1/2} + 1}$$

and should ideally be zero.

The reflection coefficient is shown plotted over S-band and X-band in Figure 2(a). This data was obtained with the coupler placed in front of small horns whose apertures were mounted flush with a ground plane. The horn aperture size in S-band (2.0 kMc/s to 5.5 kMc/s) was 1 inch by 2 3/4 inches. At X-band (5.5 kMc/s to 11.0 kMc/s) the aperture size was 1/2 inch by 4 inches. The minimum coupler to horn aperture spacing was 1/2 inch.

*Type AN-75, Emerson & Cuming Inc.

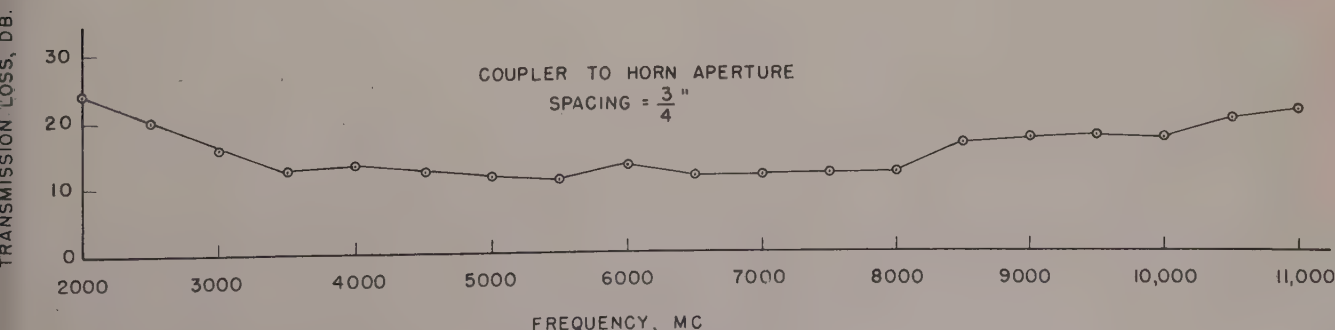


Figure 2b — Transmission loss.

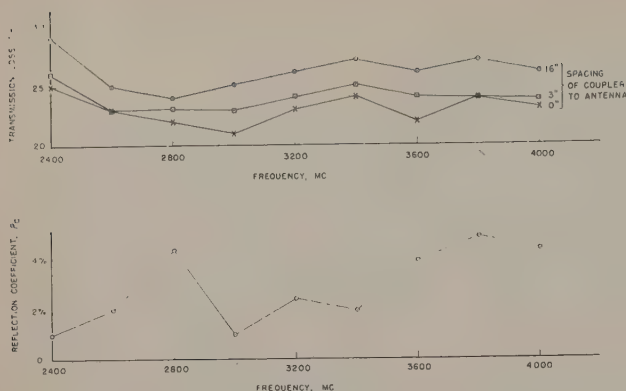


Figure 3 — Coupler performance with a large S-band horn.

The transmission loss, including coupling loss, is also important. The loss should not be so great as to make large test power necessary. It is also desirable that the loss be constant across the frequency band, although this cannot be completely controlled since it is also dependent on the characteristics of the antenna being tested.

Figure 2(b) shows the transmission loss characteristic of the coupler when used in front of the same antennas as were used for the data in Figure 2(a). The rise in transmission loss of the coupler at the lower frequencies is due to the characteristics of the spiral antenna alone. The transmission loss through the absorber is low at these frequencies whereas at X-band it increases to approximately 7 db. The reflection coefficient of the spiral antenna is almost as low at S-band frequencies without the microwave absorber in place as it is with the absorber. At X-band the effect of the absorber in reducing reflections is more significant.

A compromise is necessary regarding coupler beamwidth. If the radiation pattern is too broad, the transmission loss is increased and the coupling may become unduly sensitive to site reflections. On the other hand, the coupler radiation pattern should be moderately broad and smooth so that the coupling will not vary excessively with small changes in the relative positions of the coupler and antenna. Measurements made with the small antennas used in the tests of Figure 2 showed that the coupler could be misaligned by $\pm 1/8$ inch without changing the coupling by more than $\pm 1/2$ db from 2 kMc/s to 10 kMc/s.

The spiral antenna transmits nearly circularly polarized radiation (maximum axial ratio -1.23 from 2 kMc/s to 11 kMc/s). When using the coupler with a

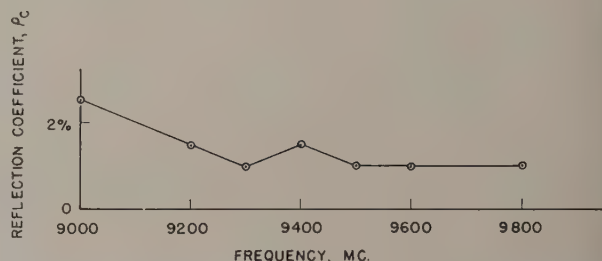
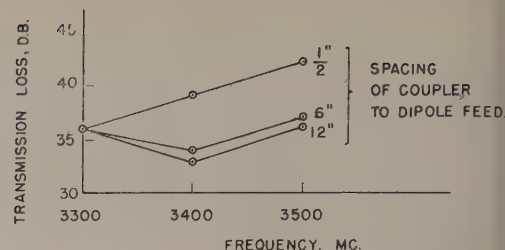


Figure 4 — Coupler performance with an X-band parabola.

linearly polarized antenna, it may be desirable to maximize the coupling for a given spacing by rotating the coupler.

Some additional tests were made with the spiral antenna coupler to show its usefulness with larger antennas. Results of transmission loss and reflection coefficient tests with an S-band horn of 11 by 10 inch aperture are given in Figure 3. Similar test results with an 18-inch X-band parabola are shown in Figure 4.

The spiral antenna coupler is particularly useful because of its good performance over a very broad bandwidth. This enables measurements to be made on many different antennas with one device. These measurements may be made periodically to check the performance of one antenna and its connected load with a power meter as the reference. When this is done, as in maintenance testing, the coupler transmission loss should be checked frequently. In another class of measurements, useful in laboratory work and production line testing, the spiral antenna coupler is ideally suited for comparative transmission measurements on antennas with similar near-fields.

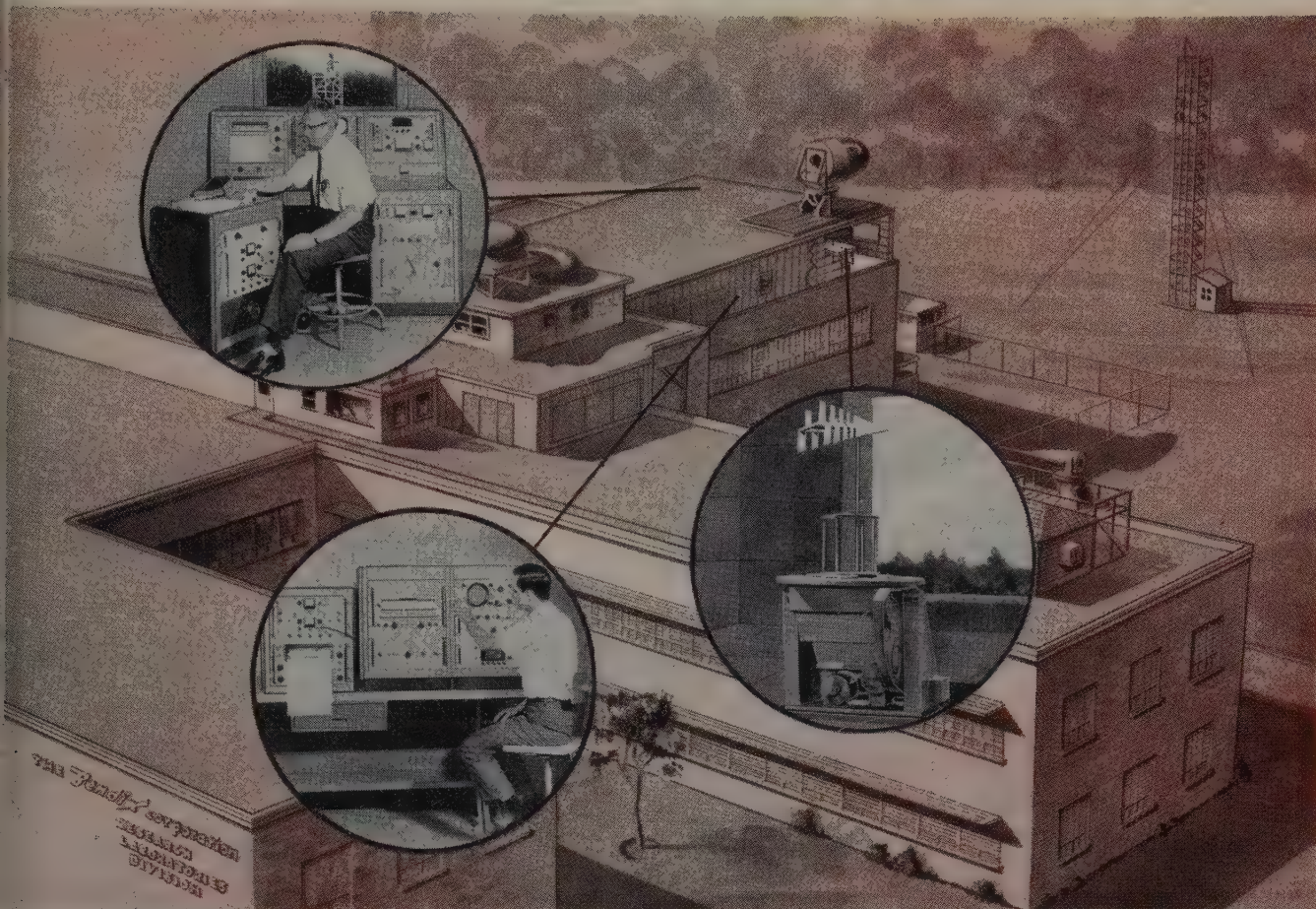
Acknowledgment

The author wishes to thank Mr. A. Staniforth for his advice concerning the design of the coupler and Mr. W. Saver and Mr. J. McDougall, who made the measurements.

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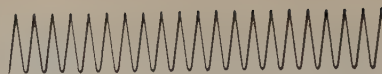


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A new high-power, 3 db, crossover, coaxial hybrid coupler has been announced by Dielectric Products Engineering Co., Inc., Raymond, Maine. The crossover feature which allows two outputs on one side provides the maximum in flexibility. Unlike many high-power microwave components, the coupler lends itself to design centers as low as 15 mc/s without becoming unreasonably large. Otherwise it has the properties of the classical $\pi/2$ hybrid.

Illustrated is an application of two such couplers to a balanced "ATR" duplexer centered at 130 Mc/s. Over a 2:1 bandwidth, receiver insertion loss is 0.3 db nominal and transmitter insertion loss is less than 0.5 db.

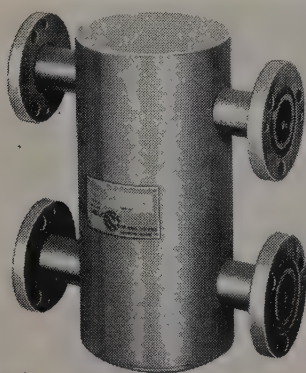


Figure 1—Crossover Hybrid Coupler*
* Patent pending

Intended for use in data link, communications, countermeasure, and other electronic equipment applications, this and a companion "TR" duplexer have a power capability of 10 kw peak, 200 watts and 500 watts average, respectively. Isolation is nominally 30 db over a 2:1 bandwidth, larger for narrower bandwidths. Using tubes especially designed for these duplexers by Tucor, Inc., recovery time is 100 microseconds. Similar units can be furnished for higher power levels.

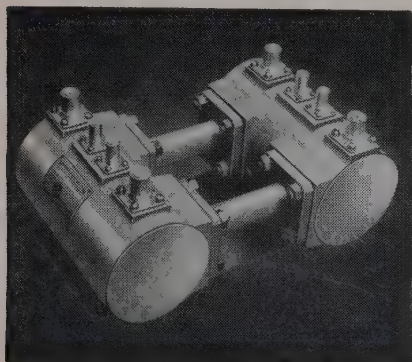


Figure 2—Duplexer employing two hybrid couplers.

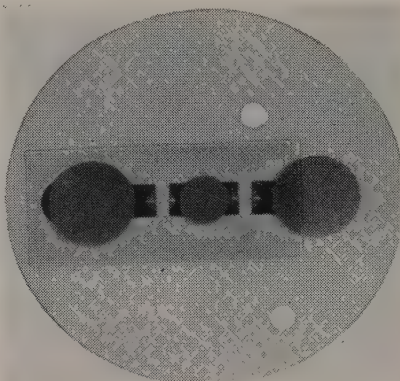
From an equipment packaging viewpoint, the coupler and networks employing it have another important feature. The angular orientation of the port pairs is unimportant. The duplexer illustrated has a 90° orientation, but any angle up to 180° can be supplied.

For further specific information on the basic coupler or networks using it as a component, direct inquiries to Proposal Engineering Department. For general information, circle Reader Service Card as indicated below.

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— m w j —

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A line of broadband disc bolometers, available in 4.5 or 8.75 ma. bias current values for use with all commercial instrumentation supplying appropriate bias, was recently introduced by the Filmohm Corp., New York, N. Y.

The bolometers feature non-tarnish, corrosion-resistant gold electrodes for maximum stability; matched 100-ohm Wollaston wire elements; a maximum VSWR of 1.5; alignment holes for accurate assembly in standard bolometer mounts; a low unit price in packs of five; immediate delivery from stock. "Contract Year" quantity discount/stepped delivery terms are also being offered on minimum orders of fifty units.

Ideally suited for attenuation and all relative or absolute microwave power measurements, Filmohm Type MWB Bolometers are checked for power sensitivity and low VSWR over the 500 to 10,000 Mc range, and stabilized for maximum power. The wire elements are series-mounted on a prepared mica base to present a 200-ohm resistance to external DC or AF bias circuits. They are arranged so as to be in parallel in the RF transmission line for a 50-ohm termination.

The square law response error is less than one per cent for power levels of 0.2 mw. using the 8.75 ma. bolometer, or 0.1 mw. with the 4.5 ma. type. Microwave power levels of 0.01 mw. to 10 mw. may

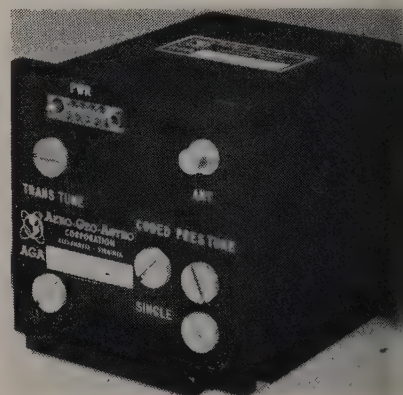
be measured with the 8.75 ma. disc and levels of 0.01 mw. to 3 mw. may be measured with the 4.5 ma. type, depending upon the power bridge employed.

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AGA RADAR TRANSPONDER FEATURES CRYSTAL VIDEO RECEIVER

The Aero Geo Astro Corporation, Alexandria, Va., AGA C/T-CV is a radar transponder for missile airborne use with instrumentation radars, where size and weight considerations are of extreme importance.



Featuring a crystal video receiver, the C-band unit weighs only 3.2 pounds and has a total volume of approximately 1 cubic inches. Comparing it to a typical superheterodyne transponder in the same frequency range, the C/T-CV weighs about 2 pounds less and is around 40 cubic inches smaller, which represents important savings in size and weight. The C/T-CV is entirely transistorized except for the transmitter tube and is designed to operate in severe environments.

Models to accommodate input voltages of either 6 VDC or 28 VDC are available. An ancillary 6 VDC battery pack is also available. Transmitter output is 100 watts and power drain is 2 amps at the 100 cps rate. Transmitter and receiver frequency are both 5400 to 5900 Mc. Receiver sensitivity is -40 dbm over the frequency range.

Single or double pulse interrogation can be selected for the receiver. Internal duplexing for single antenna operation and d-c to d-c converter are incorporated. A solid state modulator with recovery time not exceeding 160 microseconds is used. Overall dissipation at a nominal repetition rate is under 12 watts.

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(Continued on page 108)

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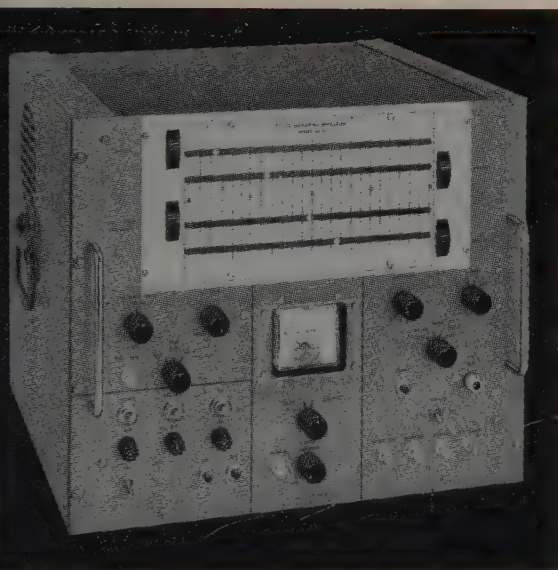
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- **Adjustable Frequency Markers**—time-saving indicators of band limits or intermediate frequency values.
- **Quick Look Readout**—shows frequency range, markers and sweep time at a glance.
- **Ten Frequency Ranges, 1 to 26 Gc**—covering 1—2; 1.4—2.5; 2—4; 4—8; 6.5—11.5; 8—12.4; 8.2—12.4; 10—15.5; 12.4—18; 15—22; 18—26.5 Gc. (Internal leveling 1 to 11 Gc only.)
- **0.5 microsecond rise and fall response to AM**—equivalent to a 2 megacycle band pass.
- **Frequency accuracy $\pm 1\%$ unswept or swept.**
- **Direct coupled external sweep connection**—response dc to 10 kc. Ideal for external frequency programming.

GET COMPLETE DETAILS—Alfred's policy is to publish specifications—not to withhold them. All specifications are guaranteed as stated. For detailed information on Series 620 oscillators, contact your Alfred engineering representative or write to:

ALFRED ELECTRONICS

3176 Porter Drive, Palo Alto, California • Phone: DAvenport 6-6496



Alfred Model 623BK Microwave Oscillator, featuring built-in leveler, drift less than $\pm 0.02\%$ per hour, adjustable frequency markers and Quick Look Readout.

New Products

(Continued from page 106)

INDIANA GENERAL OFFERS COMPLETE PPM TWT STACK ASSEMBLIES

Indiana Steel Products Division, Indiana General Corp., Valparaiso, Ind., is offering complete PPM traveling wave tube stack assemblies, designed to customer specifications. In addition to Alnico V, VI, and INDOX I, ISP now offers Alnico VIII and INDOX VI-A permanent magnets for TWT applications.

Special Indiana General calibration equipment, designed for use in connection with IGC's TWT assembly section, makes possible closer tolerances on a production basis, provides closer flux density, uniform field patterns and lower costs. Calibrating techniques also allow more latitude in tube parameters, eliminating losses of border line assemblies, and permit use of tubes formerly rejected.

Alnico VIII eliminates the need for temperature compensating elements, and permits the use of smaller TWT magnets. It has a coercive force of 1400 Oersteds and a temperature coefficient of only 1.5×10^{-6} C (approx.).

Circle Reader Service Card 104

— m w j —

HYCON MICROWAVE DIODE DETECTOR EMPLOYS THERMIONIC DIODE TUBE



Hycon Manufacturing Co., Monrovia, Cal., has announced a high-powered microwave diode detector which employs a GE "266 thermionic diode tube.

Small terminals are provided on the back of the unit for the 6.3 volt filament and 1.5 volt biasing voltage. A built-in 1 K resistor load is inserted at the output side, but this load can be easily increased to raise the detected voltage. RF matching and absorbers are provided within the unit.

Specifications of the Model HDM-1005 include: frequency—2.6 to 3.2 GC; VSWR—1.50 maximum; rise time—approximately 0.2 microseconds; and tangential sensitivity—40 dbm minimum (Using HP415B with 1000 cps ± 2 per cent video bandwidth).

Circle Reader Service Card 105

— m w j —

HIGH POWER C-BAND TWT FEATURES HIGH-MU GRIDDED GUN

Watkins-Johnson Co., Palo Alto, Cal., has announced a high-gain periodically focused 15 kw pulsed TWT amplifier for sophisticated C-band radar systems.

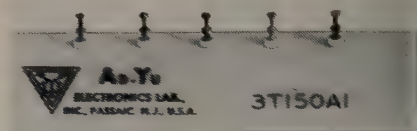
The WJ-228 features all metal and ceramic construction and is unusually small and lightweight for its power level. Featuring a high-mu gridded gun, it gives high gain performance, 30 percent efficiency, high average power and long life.

The tube utilizes the latest coupled cavity techniques in conjunction with a high convergence gun to provide reliable long life service. Production quantities now available on short delivery.

Circle Reader Service Card 106

— m w j —

MINIATURE TAPPED DELAY LINES DEVELOPED BY AD-YU



Small physical size, extreme bandwidth and fast rise time are required in many applications for tapped delay lines and fixed delay lines. Type 3T series delay lines from Ad-Yu Electronics Lab., Inc., Passaic, N. J., were developed to meet these requirements.

Group 1 of this series consists of 20 sections of m-derived networks with high-Q toroidal coils for minimizing attenuation and rise time. The delay lines in Group 2 are similar to those in Group 1, except the number of sections are increased to 30 in order to give longer delay and smaller ratio of rise time to total delay.

Type 3T has the following features: Fast rise time, less than 6 per cent of total delay; extremely low attenuation, 0.1 db per microsecond; low distortion, low overshoot, less than 2 per cent; small physical size, light weight, meets MIL specifications; maximum 30 taps can be provided on request.

This series of delay lines is very suitable to use in transistorized instruments and printed circuits, or wherever small physical size is essential. For longer delay, one can use two or more units of 3T delay lines connected in series whenever their characteristic impedances are equal. In this case, the total time delay will be the sum of each individual unit and the rise time will equal the square root of the sum of the squares of the rise time of each unit. In addition, the delay lines are embedded in resin compound to afford maximum protection from shock vibration and humidity.

Circle Reader Service Card 107

— m w j —

(Continued on page 111)

the microwave journal

- This new instrument measures unknown VSWR's and transfer characteristics directly as a function of frequency. The Type 27 Plotter measures VSWR's from 100 kc to 600 mc; transfer characteristics from 10 kc to 600 mc.
- Information is presented on a self-contained meter or on an external recorder or oscilloscope.
- Interchangeable bridges for VSWR measurements cover individual frequency ranges of 0.1-1.4 mc, 1.0-2.5 mc, 2.5-250 mc, 30-400 mc and 180-600 mc.
- Unit incorporates an amplitude-regulating power supply for external cw oscillators and can be used with constant-output sweep generators.
- VSWR full-scale ranges of $\infty:1$, 2:1, 1.2:1 and 1.07:1. Transfer-characteristic range of 80db.
- Connectors are Type N, with reducers available to other line sizes.

ALFORD
Manufacturing Company
299 ATLANTIC AVE., BOSTON, MASS.



Circle Reader Service Card 55

ON THE SHELF— ARNOLD CORES IN WAREHOUSE STOCK FOR IMMEDIATE DELIVERY

us handle your inventory problems and save you time and money on your magnetic core requirements. Extensive stocks of four types Arnold cores in the most popular sizes have been set up in our Marengo, Illinois and Fullerton, Calif. plants. Subject of course to temporary exhaustion of stock by order sales, these cores will be shipped the same day on orders received at the warehouse by 12:00 p.m. When cores are out of stock at the nearest plant, we may be able to ship within 24 hours from

the other.

Arnold core products covered by this warehouse stock program include: 1) Silectron C, E and O cores in 2, 4 and 12-mil tape. 2) Type 6T aluminum-cased cores of Deltamax, Square Permalloy and Supermalloy, in 1, 2 and 4-mil tape. 3) Mo-Permalloy powder cores, both temperature-stabilized and unstabilized types, ranging down to "cheerio" sizes. 4) Iron powder toroids, threaded cores and insert cores.

All four products are available

in a wide range of selection, for your convenience and economy in ordering either prototype design lots or regular production quantities. • Stock lists, bulletins, etc. are available—write for information. The Arnold Engineering Company, Marengo, Ill.

2099

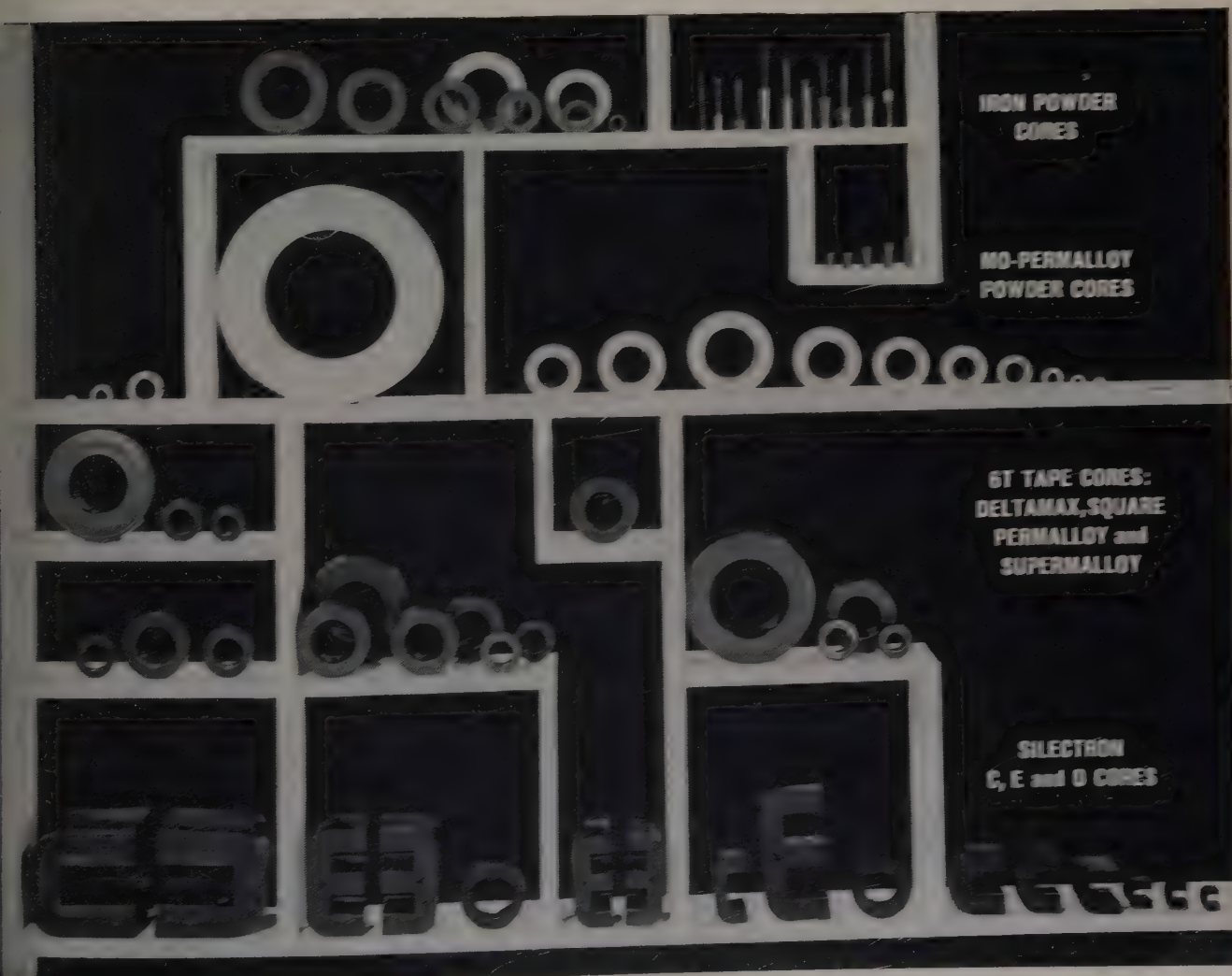
ADDRESS DEPT. MJ-12



ARNOLD

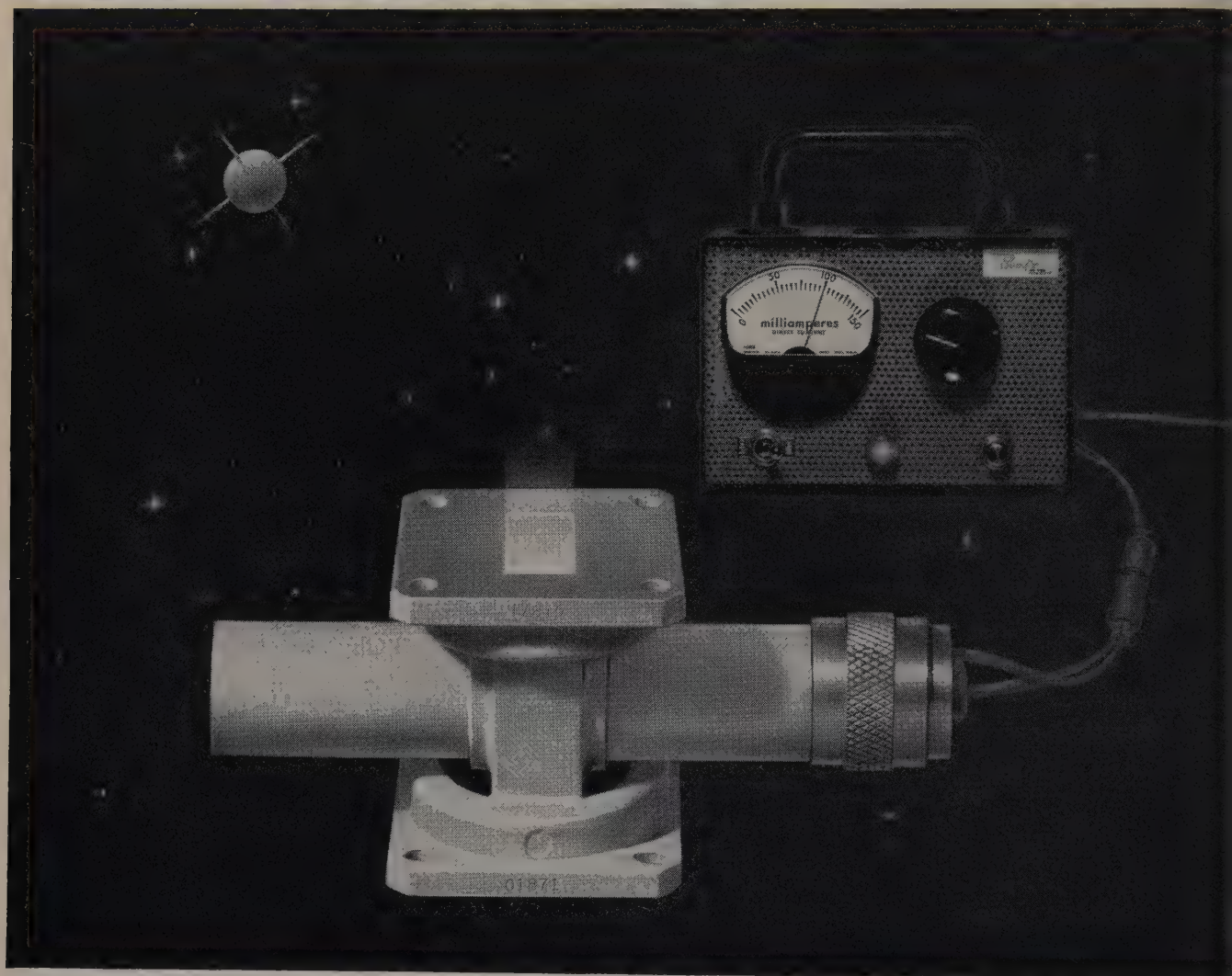
SPECIALISTS IN MAGNETIC MATERIALS

BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES • Find them FAST in the YELLOW PAGES





Bendix Craftsmanship at work for you



NEW BENDIX® 6-OUNCE NOISE GENERATOR meets need for fast, accurate noise measurement in miniaturized package. It has special value on noise monitoring applications—such as microwave and radar receivers—where size, weight, and power drain rank equally important with bandwidth. This Bendix model TN-1 is only 2.00" x 4.25" over-all, weighs a mere six ounces, features low power drain, and is ruggedly built for long, trouble-free service. Designed for transmission-type use over frequency range of 8500 to 9600 mc. For further information, write Electron Tube Products, The Bendix Corporation, Eatontown, New Jersey.

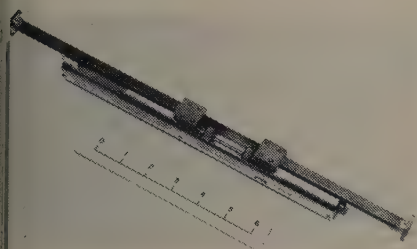
Red Bank Division



New Products

(Continued from page 108)

GE K_a-BAND TWT HAS NOISE FIGURE LESS THAN 15 DB



A K_a-band traveling-wave tube with a noise figure less than 15 db is available from General Electric's Power Tube Department, Schenectady, N.Y.

The Z-3040 has a nominal saturated power output of 3 milliwatts and operates in the range of 35,000 to 40,000 Mc. Minimum small signal gain is 20 db.

General Electric engineers say major applications for the new tube are in near-millimeter wave receiving systems.

The Z-3040 uses electromagnetic focusing. Overall package dimensions are approximately 13 x 5.5 x 5.5 inches, and weight is 16 pounds. R-f input and output connections are waveguide.

Circle Reader Service Card 108

— m w j —

HIGH POWER, MINIATURE MAGNETRONS FEATURE GROUNDED-CATHODE DESIGN

A new line of high power miniature magnetrons for pulsed or CW operation is announced by Microwave Associates, Inc., Burlington, Mass.

The MA-231 and MA-232 series are ideally suited for applications that require rugged, compact, high efficiency microwave power sources in the X-band range. The units can be fabricated to order at any fixed frequency within the bands 7.5 to 8.8 Gc/s (MA-231) and 8.8 to 10.0 Gc/s (MA-232) respectively. The standard tube center-frequency can be delivered with a tolerance of ± 25 Mc/s.

The magnetrons operate at duty ratios up to 0.05 without reduction of filament power and are recommended where peak pulse powers of 50 to 200 watts are required. The tubes will also operate, at reduced filament power, as CW sources for applications requiring 5 to 20 watts output.

Designed as compact, light weight, rugged tubes, the MA-231 and MA-232 magnetrons have successfully withstood severe environmental conditions—60G shock and 15G vibration up to 2000 cps. The inherently high efficiency of these magnetrons is due to their grounded-cathode design which greatly reduces leakage currents and enhances short pulse (nanoseconds) operation.

Circle Reader Service Card 109

— m w j —

(Continued on page 112)

December, 1961

DIPLLEXERS



AND

TRIPLEXERS

RELIABLE...LIGHT WEIGHT...LOW LOSS

The design and manufacture of missile components that exceed standard specifications is common practice at Adams-Russell. Note, for example, the characteristics of the 35 watt missile telemetry triplexer:

- * 28 db isolation and 1.0 db loss at 4 Mc separation in the frequency range 215 to 250 Mc.
- * Sealed units withstand shock to 100g ... vibration at 20g to 2000 cps.
- * No altitude limit.
- * Ambient temperature limits of -65° to $+300^{\circ}$ F.

This triplexer can be supplied with frequency separation of 3 to 10 Mc. Mounting dimensions:

4 $\frac{1}{8}$ " x 6 $\frac{5}{8}$ ". Weight: 54 ounces.

Write for additional information:

ADAMS-RUSSELL CO., INC.

200 SIXTH STREET • CAMBRIDGE 42, MASSACHUSETTS

UNiversity 8-8040

Circle Reader Service Card 58





Solve everyday problems in antenna engineering

Here's a handbook of design information to help you solve everyday problems in the design and use of antenna systems. From basic fundamentals to modern design applications, this big handbook offers you the kind of detailed treatment you need for successfully working in today's complex field of antenna engineering. Important data on many types of commercial antenna are included. In addition, a number of developments in the field of military applications are comprehensively treated to make this the most complete and useful source of antenna information available today.

ANTENNA ENGINEERING HANDBOOK

Editor-in-Chief, HENRY JASIK
Jasik Laboratories

1013 pages, 6 x 9, 993 illustrations
and charts, \$22.00

This practical volume provides a wealth of essential principles, methods, and data to help you solve all kinds of antenna problems, from designing an antenna for radiating energy in an omnidirectional pattern — to determining the lowest theoretically obtainable standing-wave ratio over a required bandwidth. The book details virtually every type of antenna. Further, it treats a wide range of areas of applications. All essential antenna system fields are fully explored. It discusses the problems of operating various systems — from low to ultra high frequencies with their special design considerations. You'll get detailed applications of the basic antenna types to a wide range of fields. In addition, you'll find a wealth of information on how to design antennas to meet particular requirements, such as techniques of impedance matching, solutions to electrical and mechanical problems in the housing of antennas. The book also includes such diverse topics as transmission lines, waveguides, radomes, absorbers, and much more.

For your copy of "Antenna Engineering Handbook" send check or money order to "the microwave journal" — Book Dept. 1330 Beacon St., Brookline 46, Mass.

Enclosed — Check ☐ Money Order ☐

Name

Address

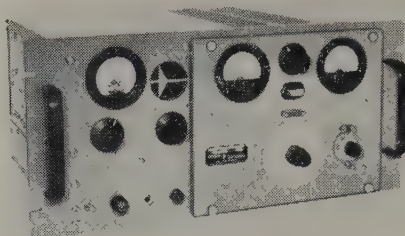
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State

New Products

(Continued from Page 111)

GEL ANNOUNCES THREE AM-FM-CW MICROWAVE TELEMETRY RECEIVERS



General Electronic Laboratories, Inc., Silver Spring, Md., announces three new AM-FM-CW dual-conversion microwave telemetry receivers meeting all IRIG (Intermediate Range Instrumentation Group) standards.

Standard coverages are: Type 20B1, 2150-2350 Mc; Type 26A1, 1700-1850 Mc; Type 22C1, 1435-1535 Mc. Each receiver has replaceable plug-in tuning heads or front ends, which permit expansion to other frequency coverages.

Designed for the reception of FM/FM, PDM/FM; PCM/FM, PAM/FM and AM data the receivers are primarily for ground station use. However, with available vibration mountings, they can be used in airborne applications. Crystal-controlled or continuous tuning modes are selected by a front panel switch. A hybrid vacuum-tube varactor multiplier local oscillator produces the 50 Mc IF. The second IF, at 10 Mc, is available in a choice of 0.75 Mc, 1.5 Mc, or 2.0 Mc, or other bandwidths. This stage has a vernier-controlled local oscillator for a ± 250 kc tuning adjustment.

The receivers achieve better than 60 db image rejection, excellent FM capture characteristics and frequency stability. The AGC system extends the dynamic range to accept signals as strong as 100,000 microvolts without overloading any amplifier.

General Specifications: power requirements: 115 VAC, 60 cps, 200 watts; size: 8-3/4 inches x 19 inches x 16 inches; weight: approximately 48 pounds; cooling: unit includes fan with removable air filter; mounting: standard conventional relay rack; specials available on order; finish: to customer order.

Circle Reader Service Card 110

— m w j —

KEARFOTT ANNOUNCES L-BAND TRANSPONDER TEST SET

Kearfott Division of General Precision, Inc., Van Nuys, Cal., announces that it will advise price and delivery information on the ATC L-Band Transponder Test Set, Kearfott Model No. C991 500 001.

Features included in the Test Set are: compatible to ARINC 532C specification, simulates all ATC Beacon and Military interrogation modes; simulates two- or three-pulse interrogation with side lobe suppression; strip transmission line circuits reduce weight and bulk; accurate, calibrated

attenuators for measuring power and sensitivity; and high Q wavemeter for measuring frequency.

The set, rack or cabinet mounted, generates video suppression pulse, video pulse for external synchronization, and has internal or external triggering capability.

The unit price is \$3,450.00 F.O.B. Van Nuys, Cal., and delivery is approximately 45-60 days after receipt of firm order. Terms are net 30 days.

Circle Reader Service Card 111

— m w j —

PRD NOISE GENERATOR MEASURES NOISE IN 30 — 1000 MC RANGE



PRD Electronics, Inc., Brooklyn, N.Y., subsidiary of Harris-Intertype Corp., microwave and electronic test equipment manufacturer, announces the addition of the PRD 904-A VHF-UHF noise generator to its line of electronic instrumentation.

The noise generator is a portable compact instrument measuring 10-1/3 inches high x 7-3/4 inches wide x 10 inches deep and weighs 20 pounds.

The PRD 904-A conveniently measures receiver and amplifier noise factors in the VHF-UHF range from 30 to 1000 Mc. The noise figures between 0 and 20 db can be read directly on the front panel meter. By means of simple calculations, noise figure measurements can be extended beyond 20 db.

On the front panel, the generator features a continuously variable output signal level control knob, a lever switch which permits shifting from the 10 to the 20 db meter scales, and a type "N" output connector. Power requirements for the new unit are 115 volts, 60 cps and 60 watts ac. An internal blower is provided in the supply to insure continued optimum service over long periods of operation.

Circle Reader Service Card 112

— m w j —

(Continued on page 115)

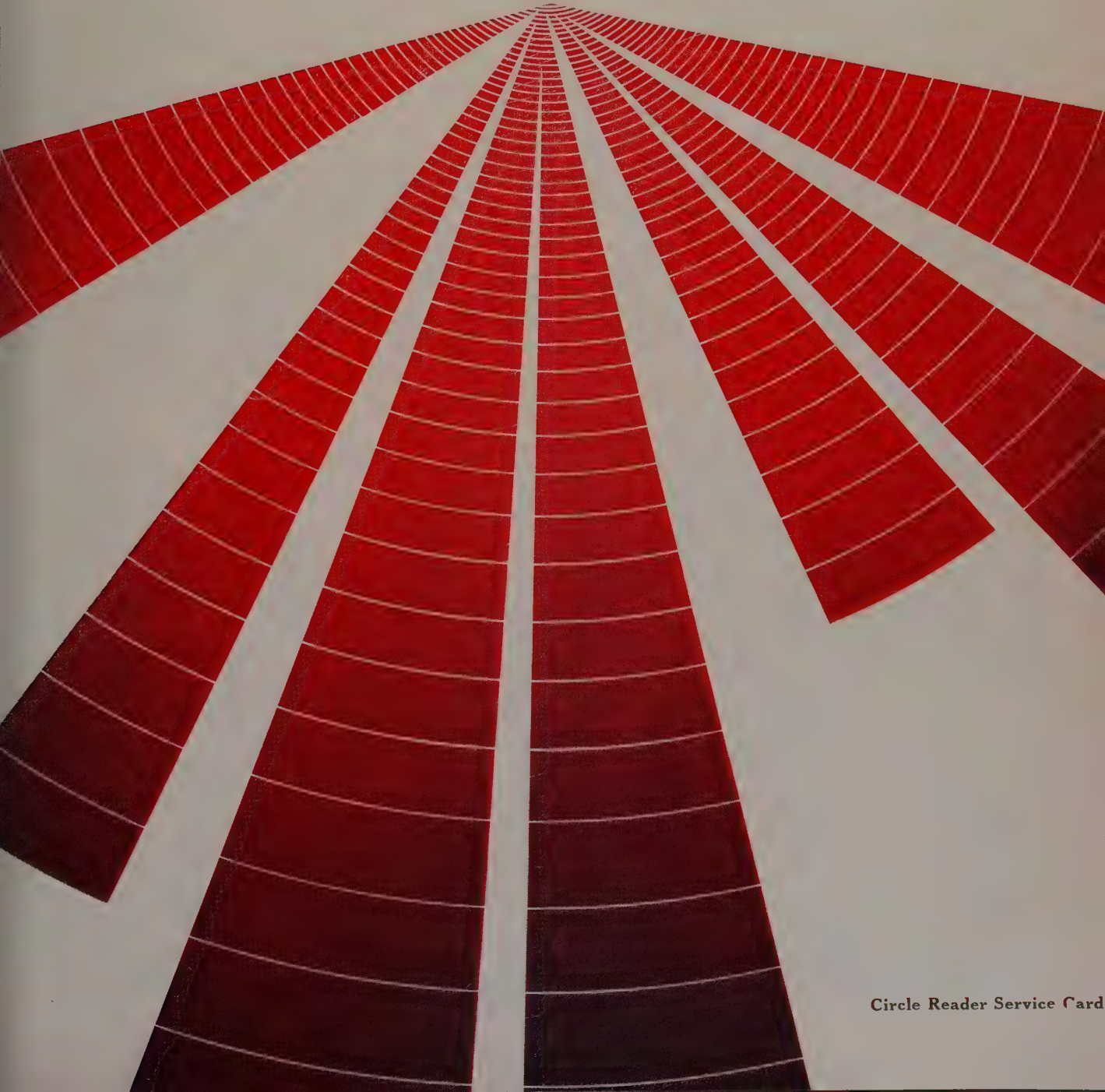
the microwave journal

COMMAND RANGE

Now you can command the full range of Cain & Company's specialized microwave capabilities—nationwide coverage... proven microwave components... on-the-spot assistance of experienced microwave specialists. Through its nationwide representation of the **SPERRY ELECTRONIC TUBE DIVISION**, **REMANCO**, **TRAK ELECTRONICS** and **TRAK MICROWAVE**, Cain & Company offers the most advanced klystrons, traveling wave tubes, backward wave oscillators, miniature microwave signal sources, harmonic multipliers, radar simulators, beacon test sets, radar performance monitors and specialized receivers. Your nearby Cain & Company representative will be glad to discuss your microwave system design problems with you. Give him a call.

CAIN & COMPANY 2615 WEST MAGNOLIA BOULEVARD, BURBANK, CALIFORNIA

Offices in: **NEW YORK** (Great Neck), **CHICAGO**, **ST. PETERSBURG**, **BOSTON** (Lexington), **PHILADELPHIA**, **WASHINGTON, D.C.**, **DAYTON** (Yellow Springs), **DALLAS** (Irving), **ALBUQUERQUE**, **SAN FRANCISCO** (Los Altos), **SAN DIEGO**, **SEATTLE**



QUIET, PLEASE — THIS IS THE MOMENT OF TRUTH

Here, hooked up to a 3-million watt uhf transmitter, a Metcom duplexer meets its moment of truth. The engineer flicks a dial, reads the oscilloscope and carefully measures its recovery time . . . still another in a long series of performance checks the duplexer must pass before it leaves Metcom's plant.

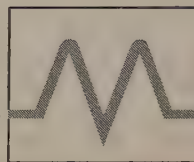
High power equipment like this (we have similar equipment for microwave tube and component testing at all frequency bands) is representative of the complete and thoroughly modern test facilities Metcom keeps on tap to make absolutely certain that any microwave tube or component bearing our name performs up to specifications.

Whatever your requirements in microwave equipment, *make sure it's by Metcom . . . because Metcom makes sure.*

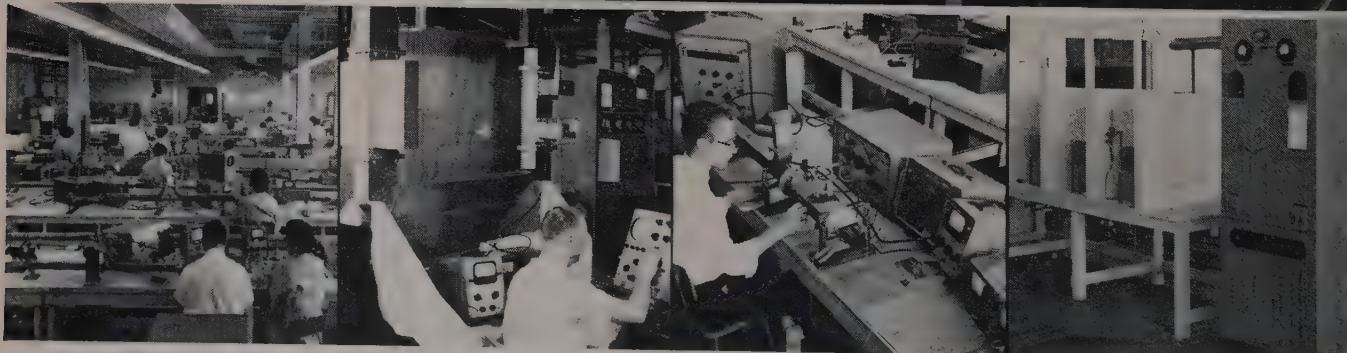
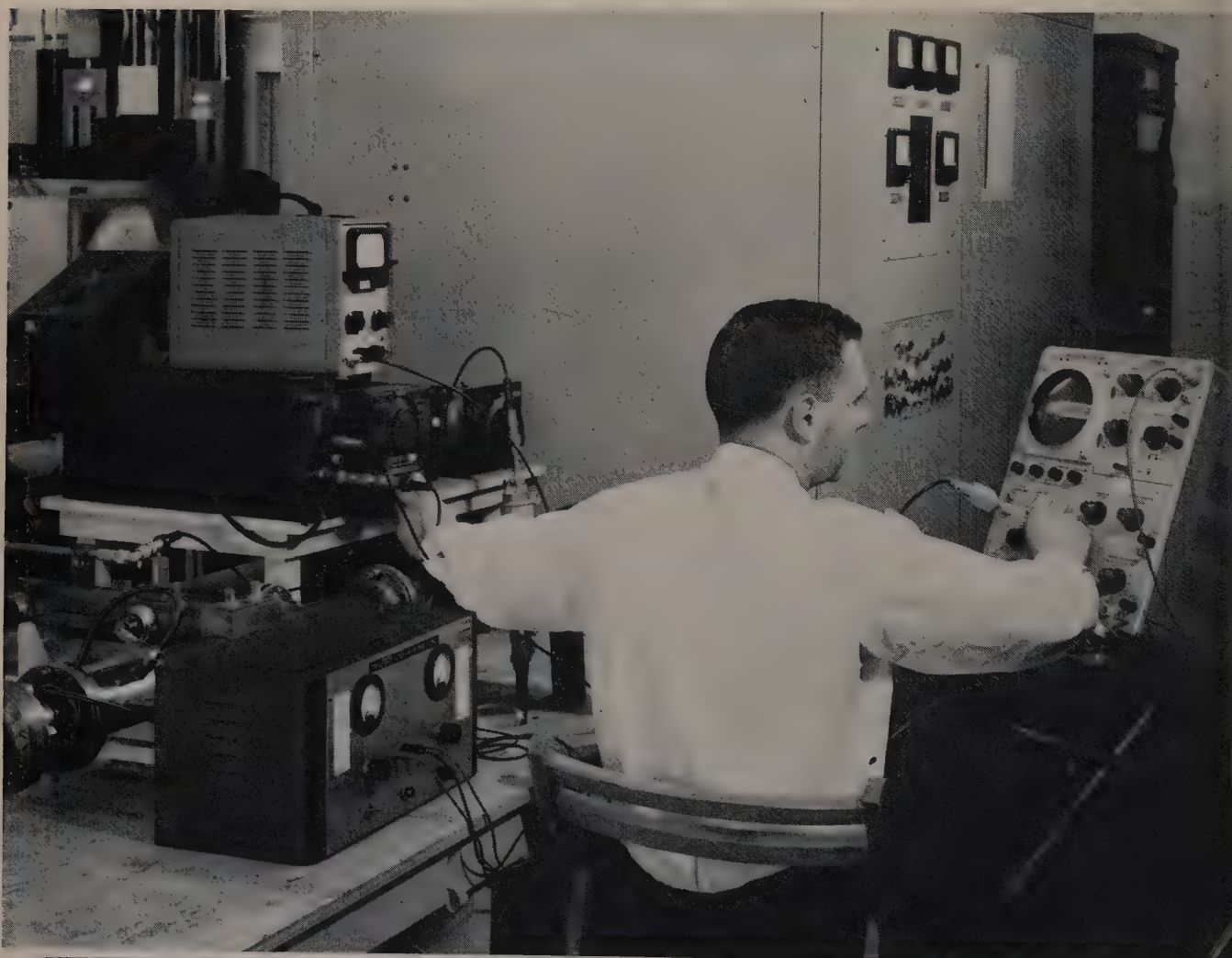


Write for our folder containing brief specifications on over 300 microwave tubes and devices.

for better microwave tubes and devices



METCOM INC.
SALEM, MASSACHUSETTS



Assembly area for TR tubes

L-band high power simulator

Low level S-band test bench

RF induction brazers

New Products

(Continued from page 112)

WESTINGHOUSE ANNOUNCES HIGH-RELIABILITY CATHODE RAY TUBE



A high-reliability cathode ray tube (type WX 4545) is available from the Westinghouse electronic tube division, Elmira, N.Y. It is a ruggedized 7-inch-diameter display tube with electrostatic focus and magnetic deflection.

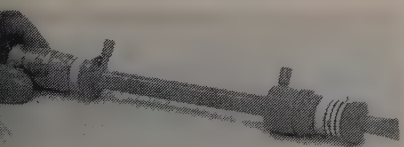
The ruggedized construction permits the tube, when mounted in a nonamplifying structure, to be used in equipment that will pass MIL-E-5422 paragraph 4.2.1.1, increased in severity as follows: 1.—vibration test at double amplitude shall be 0.120 inch from 5 to 55 cycles per second; and 2.—acceleration level shall be 20 G's from 55 to 500 cycles per second.

The tube features a 70 degree deflection angle and a 7/8-inch neck diameter for decreased deflection power, thereby making it suitable for transistorized applications. In addition, the tube is compact and lightweight. The faceplate is of clear glass and uses an aluminized screen for increased brightness. The relatively low anode operating voltage is 8000 volts.

Circle Reader Service Card 113

— m w j —

SPERRY'S MINIATURE TWT HIKES POWER, BANDWIDTH FOR SPACE COMMUNICATION



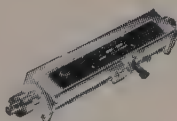
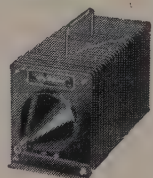
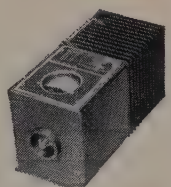
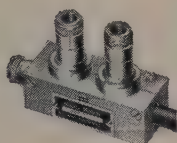
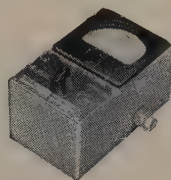
A miniature traveling-wave tube to provide high power and broadened bandwidth for space communication systems is now in pilot production at the Sperry Electronic Tube Division, Gainesville, Fla., Great Neck, N. Y., it was announced recently.

The amplifier—called the STX-186—can produce more than ten watts over frequency ranges from 5000 to 11,000 megacycles to hike the power of a great number of signals between a satellite and earth or between satellites tens of thousands of miles apart.

(Continued on page 117)

DIRECTIONAL COUPLERS • RF LOAD RESISTORS COAXIAL TUNERS • RF WATTMETERS • VSWR METERS

MicroMatch® RF Power and VSWR measuring instruments are rugged and accurate in both field and laboratory use. The patented circuit produces an output essentially independent of frequency. Over 3800 models of coupler units available. MICRO-MATCH instruments meet highest government and commercial standards, combine highest quality with low cost.



RF POWER and VSWR Instruments			
Model No.	Frequency Range (mcs.)	Power Range Incident & Reflected (watts)	RF Connectors and Impedance
263	0.5 - 225	0 - 10; 100; 1000	Type N* 52 ohms
706N	28 - 2000	0 - 400	Type N* 52 ohms
711N	25 - 1000	0 - 30; 75; 300	N plus 83-1R Adapters
712N	25 - 1000	0 - 2.5; 5; 10	N plus 83-1R Adapters
722N	1000 - 3000	0 - 4	Type N 52 ohms
723N	1000 - 3000	0 - 12	Type N 52 ohms
405B8	28 - 2000	0 - 4000	1 1/2" Flange 51.5 ohms
445A10	20 - 2000	0 - 40,000	3 1/8" Flange 50.0 ohms

DC OUTPUT DIRECTIONAL COUPLERS			
Model No.	Frequency Range (mcs.)	Power Range Incident & Reflected (watts)	RF Connectors and Impedance
576N1	42 - 2000	1.2	Type N* 52 ohms
576N6	28 - 2000	0 - 400	Type N* 52 ohms
596N2	1000 - 3000	0 - 4	Type N 52 ohms
596N3	1000 - 3000	0 - 12	Type N 52 ohms
402B8	28 - 2000	0 - 4000	1 1/2" Flange 51.5 ohms
442A9	28 - 2000	0 - 12,000	3 1/8" Flange 50.0 ohms

RF INPUT DIRECTIONAL COUPLERS			
Model No.	Frequency Range (mcs.)	Coupling Attenuation	RF Connectors and Impedance
313N3	300 - 2000	30 db	Type N* 52 ohms
313N5	60 - 2000	50 db	Type N* 52 ohms
442A40	200 - 1000	40 db	3 1/8" Flange 50.0 ohms

ABSORPTION TYPE RF WATTMETERS			
Model No.	Frequency Range (mcs.)	Power Range (watts)	RF Connectors and Impedance
621N	1 to over 1000	0 - 120 milliwatts	Type N* 52 ohms
625C5	50 - 1000	0 - 120	Type C 52 ohms
651N	25 - 1000	0 - 25; 100; 500	Type N 52 ohms
611A7	50 - 1000	0 - 1200	3 1/8" Flange 50 ohms
612A	44 - 1000	0 - 6000	3 1/8" Flange 50 ohms

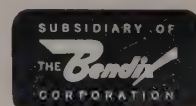
RF LOAD RESISTORS			
Model No.	Frequency Range (mcs.)	RF Power Dissipation (watts)	RF Connectors and Impedance
603N	3000	20 (air cooled)	Type N 52 ohms
633N	3000	50 (air cooled)	Type N* 52 ohms
636N	3000	600 (air cooled)	Type N* 52 ohms
638A	2000	6000 (water cooled)	3 1/8" Flange 50.0 ohms

CALORIMETRIC TYPE Primary Standard of RF Power			
Model No.	Frequency Range (mcs.)	Power Range	RF Connectors and Impedance
641N	0 - 3000	0 - 3; 10; 30; 100; 300	Type N 52 ohms

COAXIAL LINE TUNERS			
Model No.	Frequency Range (mcs.)	Range of Correction	RF Connectors and Impedance
151N	200 - 1000	Tunes a load with a VSWR of 2.00 max. down to a VSWR of 1.00	Type N 50 ohms
152N	500 - 4000		Type N 50 ohms

For more information, write us at 185 N. Main Street, Bristol, Conn.

M. C. Jones Electronics Co., Inc.



look into Panoramic's new **SPA-4a** exclusive features for more reliable spectrum analysis 10 mc to 44,000 mc

2 to 4 TIMES THE USABLE SENSITIVITY

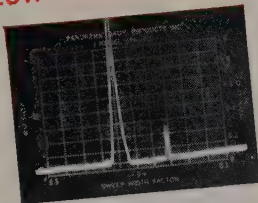
Lower internal noise enables analysis of even smaller signals than before (see chart)... accurate measurement of more highly dispersed energies, as typified by extremely narrow pulsed signals.

BAND	RF SENSITIVITY*
1- 10 — 420 MC	-100 to -110 dbm
2- 350 — 1000 MC	- 95 to -105 dbm
3- 910 — 2200 MC	-100 to -110 dbm
4- 1980 — 4500 MC	- 90 to -100 dbm
5- 4.5 — 10.88 KMC	- 90 to -100 dbm
6- 10.88 — 18.0 KMC	- 85 to -100 dbm
7- 18.0 — 26.4 KMC	- 70 to - 90 dbm
8- 26.4 — 44.0 KMC	- 60 to - 85 dbm

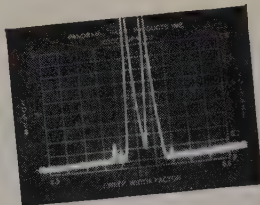
*measured when signal and noise equal 2x noise

EXCEPTIONALLY LOW DISTORTION

Reduced threshold allows SPA-4a to operate at smaller input signal levels (and attenuated larger ones). Untouched screen photos show how this permits virtually spurious-free measurement—over a wide dynamic range—of harmonics, in-band distortion, and other weak signals in the presence of strong ones.



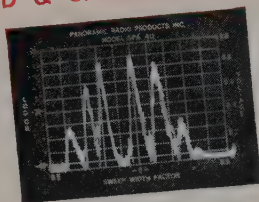
Extended dynamic range comparison of 2 signals on SPA-4a. Larger is +15 db over full scale log. Smaller is at -28 db on scale or -43 db from larger. Note exceptional freedom from spurious. (Photo not retouched)



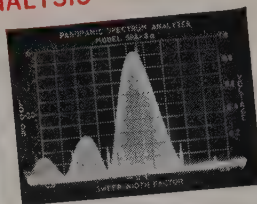
Distortion analysis illustrates SPA-4a wide range linearity. Odd-order distortion here is measured more than 50 db below level of 2 main tones (deflected 20 db above full scale). Photo unretouched.

HIGHLY RESOLVED & CALIBRATED ANALYSIS

Reduced internal hum improves resolution of closely spaced signals; also improves minimum dispersions for more highly magnified analyses. Marker modulation permits highly accurate measurements of frequency differences during high speed analysis. See photos.



Narrow band 20 kc dispersion analysis shows unique resolution capability. Here, a 1000 mc FM signal with 2 kc modulation is seen near first carrier null. Photo unretouched.



Pips of internal marker and sidebands (ext. mod. ~100 kc) accurately measure pulse width in spectrum of 10μs. radar pulse. Upper lobes seen to be very small. (Unretouched)



Important as these advantages are, there are many more.

Easy to use, too... human engineered for simple operation, component accessibility.

The advanced new SPA-4a is unmatched for visually analyzing FM, AM and pulsed signal systems—instabilities of oscillators—noise spectra—for detection of parasitics—studies of harmonic outputs, radar systems and other signal sources.

Write, wire, phone today for detailed SPA-4a specification bulletin and new Catalog Digest.



Formerly Panoramic Radio Products, Inc.
the pioneer is the leader

Sec. 2900



The SPA-4a's exclusive features also include:

- ONE TUNING HEAD** — 10 mc to 44,000 mc, utilizing 3 stabilized, low hum local oscillators (1 HF triode and 2 klystrons). Fundamentals to 11 kmc. Direct reading with $\pm 1\%$ accuracy.
- TWO INDEPENDENT FREQUENCY DISPERSION RANGE** Continuously adjustable; 0-70 mc with exceptional flatness, stable 0-5 mc for narrow band analysis. Both swept local oscillators operate on fundamentals only for spurious-free analysis.
- PUSH-BUTTON FREQUENCY RANGE SELECTOR.**
- ADJUSTABLE IF BANDWIDTH** 1 KC to 80 KC.
- 3 CALIBRATED AMPLITUDE SCALES** — 40 db log, 20 db lin, 10 db power.
- SYNCHROSCOPE OUTPUT WITH 40 DB GAIN.**
- SWEEP RATE ADJUSTABLE FROM 1-60 CPS.** May be set free running, synchronized to the line or to external prf. Also provisions for sweep rate calibrations.

PANORAMIC ELECTRONICS, INC.

556 South Fulton Avenue, Mount Vernon, N. Y. • Phone: OWen
TWX: MT-V-NY-5229 • Cables: Panoramic, Mount Vernon, N. Y.

(Continued from page 115)

To generate the high output power of the STX-186, Division engineers perfected an electron beam focusing structure to insure the exact aiming of highly concentrated electrical energy down the length of the tube. Tiny permanent magnets made of a special alloy are slipped like a row of precisely spaced finger rings over the tube to form the focusing structure. The STX-186 is a second-generation extension of an earlier and lower power band traveling wave tube designed for electronic radar jamming systems. It is the first available version of the STX-182 experimental tube announced by Sperry last spring.

Circle Reader Service Card 114

— m w j —

PRD ADDS KLYSTRON POWER SUPPLY TO ITS INSTRUMENTATION LINE



PRD Electronics, Inc., Brooklyn, N.Y., subsidiary of Harris-Intertype Corp., microwave and electronic test equipment manufacturer, announces the addition of the PRD 809-A Klystron Power Supply to its line of electronic instrumentation.

This Klystron Power Supply is a light portable compact instrument measuring 11-1/2 inches high by 7-3/4 inches wide by 15 inches deep and weighs 38 pounds.

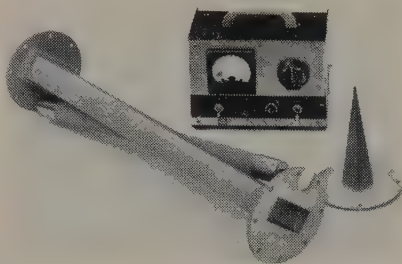
The PRD 809-A contains regulated beam voltage 250 to 600 volts, 0-65 ma; regulated 0 to 900 volts reflector voltage and 5.3 volt a-c filament supply. Reflector voltage may be either unmodulated or internally modulated by square wave or sawtooth. This instrument supply has improved reflector voltage resolution and less than 1 mv rms ripple.

New design of planetary gears in the PRD 809-A provide for finer adjustment of reflector voltage. Improved designs also include an internal blower, built-in cabinet tilt stand and a PRD expansion coil cord with polarized ac plug. Direct reading of beam voltage or current can be obtained on the front panel meter which is calibrated in volts and milliamperes.

Circle Reader Service Card 115

— m w j —

**TEMPERATURE-INDEPENDENT
RANDOM NOISE GENERATORS
FEATURE BUILT-IN MATCHED
TERMINATION**



For use in the laboratory or in field systems requiring the measurement of noise figure and receiver sensitivity, Model 501 Random Noise Generators in six waveguide sizes covering the frequency range from 2.6 to 18.0 GC are available from General Microwave Corp., Farmingdale, N.Y.

All models in the series feature the use of argon gas discharge tubes whose output is independent of ambient temperature. Each of the waveguide models in the Model 501 Series Random Noise Generators is supplied with a matched termination (VSWR less than 1.03) as standard equipment, so designed that its inclusion does not add to the normal length of the waveguide mount.

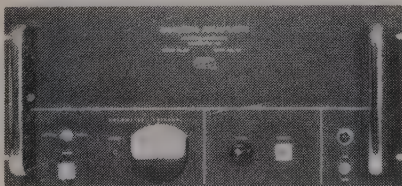
The matched termination is readily removable, leaving available a standard waveguide flange for connection to other waveguide components or signal sources.

The nominal excess noise power ratio, which varies from 15.2 to 16.0 db, depending upon waveguide size, is constant over the waveguide operating frequency range and uniform from instrument to instrument within ± 0.2 db. Each of the waveguide noise sources in the 501 series is designed to operate with Model 301 Universal Power Supply which contains provisions for controlling and monitoring the lamp current.

Circle Reader Service Card 116

— m w j —

**WEINSCHEL ELECTRONIC
PRODUCTS UNDERGO EXTENSIVE
IMPROVEMENT PROGRAM FOR
EXPORT**



Weinschel Engineering, Kensington, Md., has announced the first results of its long range product improvement program designed to supply all its electronic instruments to operate well for any line frequency between 50 and 60 cycles and at nominal line voltages of either 115 volts or 230 volts with a high degree of

(Continued on page 118)

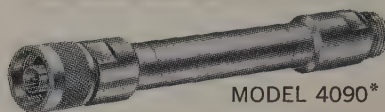
COAXIAL ATTENUATORS IN STOCK

Low cost, compact attenuators for system and laboratory, on the shelf for immediate delivery. Models 4080 and 4090 feature short insertion length, stable impedance and flat frequency response over wide ranges of temperature and humidity.



MODEL 4080*
Price \$35

Frequency.....	DC — 3 Kmc/s
VSWR.....	1.25
Attenuation.....	3, 6, 10, or 20 db
Power.....	2 watts average, 1 Kw peak
Insertion Length.....	2 3/4 in.
Connectors.....	Type "N"
Finish.....	Rhodium over nickel plate



MODEL 4090*
Price \$35

Frequency.....	2 — 10 Kmc/s, or 2.4 — 10 Kmc/s (useable to 12.4 Kmc/s)
VSWR.....	1.3 (1.4 at 20 db)
Attenuation.....	3, 6, 10, or 20 db
Power.....	2 watts average, 1 Kw peak
Insertion Length.....	5 1/4 in.
Connectors.....	Type "N"
Finish.....	Rhodium over nickel plate

*To order, prefix model number:
NA, 3 db; NB, 6 db; NC, 10 db; ND, 20 db

call or write for complete data

**BOGART
MANUFACTURING
CORPORATION**

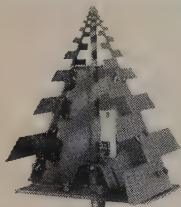
315 SEIGEL STREET
BROOKLYN 6, N.Y.

BOGART

HYacinth 7-4972

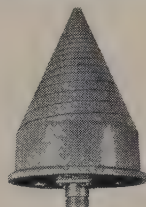
serving the industry since 1942

FREQUENCY INDEPENDENT ANTENNAS



Model No. APN101A

LOG PERIODIC
LINEAR
POLARIZATION



Model No. ALN108A

CONICAL HELIX
CIRCULAR
POLARIZATION

MODEL NO.	FREQUENCY	MODEL NO.
APN105A	0.05-3.0 Gc	ALN112A
APN106A	0.3 -3.0 Gc	ALN119A
APN101A	1.0-11.0 Gc	ALN108A

The above AEL antennas represent an extensive line of both log periodic and patented conical helix antennas... all designed to meet today's dynamic requirements of electronic countermeasures, telemetering and communications systems.

High Gain, broadband performance can be obtained by employing the Conical Helix and Log Periodic feeds with parabolic reflectors. The fundamental limitation to gain-bandwidth of the parabolic configuration is defocusing caused by the phase center movement of the feed. In spite of this limitation; however, 15:1 bandwidths have been achieved with gains in the order of 15 to 30 db. Conical Helix or Log Periodic fed parabolic reflector antenna systems will be quoted on request.

Small volume—Light weight—Rugged Construction—Built for military usage

Investigate the opportunities at AEL for creative engineers



AMER. ELECT. LABS., INC.
Richardson Rd., Colmar, Pa. • Van Dyke 2-0131

In Canada contact: Conway Electronic
Enterprises Regd. Toronto, Canada

New Products

(Continued from page 117)

power supply regulation even for combines changes in line voltage and frequency.

This improvement provides a standard instrument for shipment to the export market.

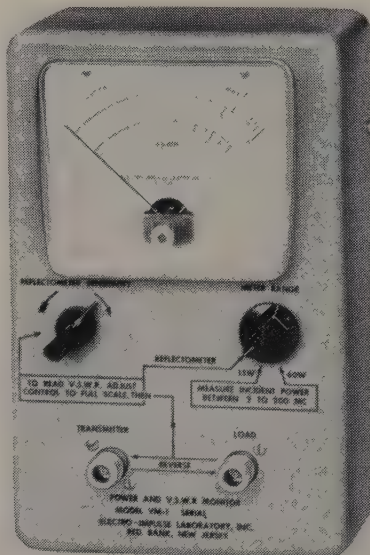
The first two instruments to come off the production line as a result of this product improvement program are Models BA-1D and MO-1C. The BA-1D is a high gain, low noise, linear amplifier designed primarily as a bolometer preamplifier to be used in Weinschel Engineering's Insertion Loss Measuring System.

The Model MO-1C is a highly stable 1 kc modulator with both sine wave and square wave outputs derived from either a fixed 1000 cps plus or minus .01 per cent tuning fork oscillator or a very stable 1000 cps Wien Bridge oscillator which is variable over a 30 cps range.

Circle Reader Service Card 117

— m w j —

ELECTRO-IMPULSE LAB ANNOUNCES TWO RF POWER METERS



A feed-thru power meter, Model VM-2, covering the range of 1 to 30 Mc, and a VSWR Power Meter, Model VM-1, covering the range of 10 to 200 Mc, are announced by Electro Impulse Laboratory, Inc., Red Bank, N. J.

The RF power meters consist of a voltage divider of the feed-thru type and a reflectometer. The frequency range of the voltage divider is DC to the upper frequency limit of the instrument.

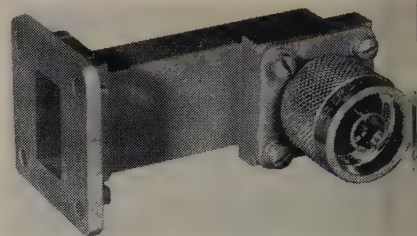
A crystal diode across a portion of the voltage divider measures the RF voltage which is indicated on a volt meter calibrated in watts. Because of this feature, the voltage divider can be calibrated at power line frequencies.

The reflectometer has sufficient sensitivity to pick up the forward and reflected power in the frequency range of the instrument.

Circle Reader Service Card 118

— m w j —

AEL INTRODUCES LINE OF WAVEGUIDE TO COAXIAL ADAPTERS



AEL, Inc., Colmar, Pa., has introduced a complete line of waveguide to coaxial adapters, with type N male and female connectors.

The adapters are available in waveguide sizes from WR187 (3.95-5.85 Gc) to WR28 (26.5-40.0). The higher frequency units (above 12.4 Gc) are designed for use in the extraction of high harmonic frequencies from relatively low frequency sources that terminate in type N connectors, such as the AEL Model T601 Traveling Wave Tube Amplifier.

Above 15 Gc because of the generation of higher order modes in the coaxial adapter, high insertion loss occurs, but in many cases this loss can be tolerated and a useful signal still obtained.

All units are supplied with plate flanges as standard. Choke flanges can be supplied on request. Prices may vary from \$25.00 to \$95.00 depending on frequency.

Circle Reader Service Card 119

— m w j —

CALIBRATION SERVICE FOR BOLOMETER MOUNTS MADE AVAILABLE BY WEINSCHTEL

The Weinschel Engineering Company, Kensington, Md., announces a complete calibration service for coaxial or Thermistor Mounts up to 4 kMc.

The service is limited, at present, to those mounts having a dc resistance of 200 ohms for bias currents of from 4 to 13 milliamperes.

Mounts to be calibrated must be mechanically stable with an input VSWR in a coaxial 50 ohm system of less than 1.30. Tuning elements, if any, must be fixed since they will be sealed prior to calibration so that they cannot be moved. Accuracy of the determination of the "calibration factor" is ± 2 per cent or better.

The frequency range in which these calibrations are available is 100 Mc to 4 kMc. Standard calibration frequencies are 400 Mc, 1500 Mc, 2000 Mc, 3000 Mc and 4000 Mc. The cost of calibration for standard frequencies is \$150.00 per mount. Calibration at any other frequency between 100 Mc and 4 kMc is \$250.00 per mount.

Four week service, from date of receipt of mount, is offered by the company.

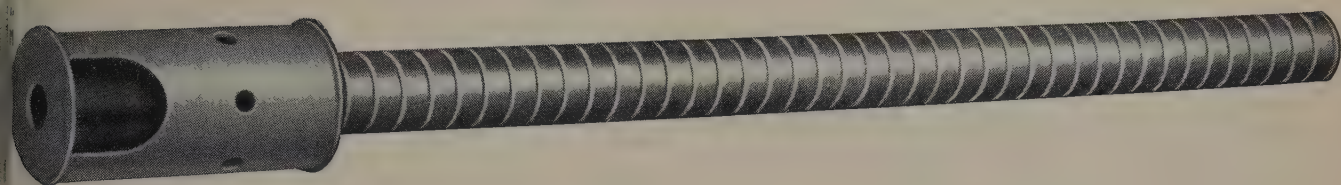
Circle Reader Service Card 120

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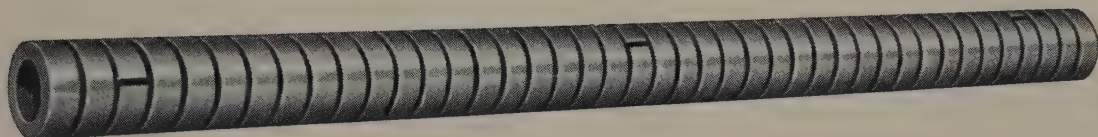
(Continued on page 120)

the microwave journal

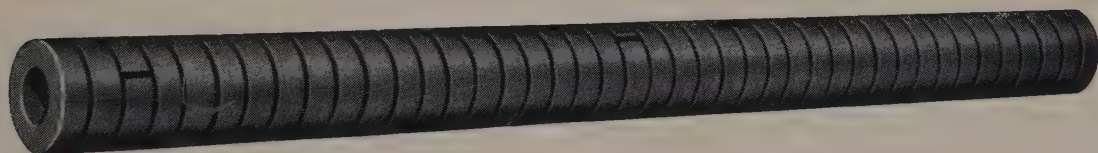
TWT Stacks... Custom Designed or Do-It-Yourself



Complete PPM TWT Stacks... Lower Cost



Alnico VIII... Lowest Temperature Coefficient



INDOX[®] VI-A... Highest Field Strength

Now, only from Indiana General Corporation, do you have a complete choice.

TWT stacks built to your specifications; specially calibrated on a production basis for closer flux density, uniform field patterns and lower cost. Another plus, more latitude in tube parameters, eliminating losses of border line assemblies.

If you build your own TWTs, select the magnet material that meets your needs. Alnico VIII eliminates temperature-compensating elements and

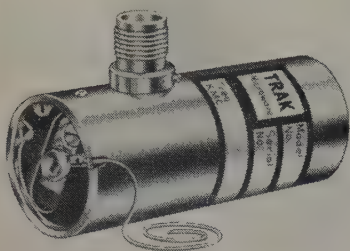
shrinks TWT size. INDOX VI-A provides the highest coercive force of any commercially available magnet material, better resistance to low temperatures, high residual induction and peak energy product, plus magnetizing before assembly.

TWT stacks are only one example of Indiana's leadership in magnetic experience, materials and equipment. Bring all your permanent magnet assembly problems to us for fast, efficient solutions. Write for Bulletins, describing INDOX VI-A — Alnico VIII.



INDIANA GENERAL CORPORATION
INDIANA STEEL PRODUCTS DIVISION, Valparaiso, Indiana

TRAK TYPE 2970 (CW)
Diameter 7/8", Length 2"
Weight 3 Ounces



TRAK STOCK ITEM:

Our Smallest Local Oscillator For Entire C-Band

Our smallest local oscillator to tune the entire C-Band is now in production. It features high overall power efficiency and more power output than was previously available. It can be furnished with temperature stabilities of less than 1 Mc total drift for 100°C temperature change.

TYPICAL SPECIFICATIONS

Frequency:

Tuneable from 5.2 Gc to 6.0 Gc by adjusting a screw located on one end of the C-Band Cavity.

Power Output:

Greater than 10 mw from 5.4 to 5.9 Gc. Greater than 5 mw over the entire band.

Power Input:

175 V DC at approximately 13 ma; 6.5 V @ 240 ma.

Temperature Stability:

Less than ± 2 Mc drift from -20°C to $+105^{\circ}\text{C}$. Greater stability available.

Mounting:

Engineered to customer specifications.

WE'D LIKE TO TACKLE YOUR ENERGY SOURCE PROBLEMS, PHONE COLLECT:
Tampa 876-6422 or Tampa 876-6407.

Typical stock oscillators are included in Catalog 61-A. Available upon request.

TRAK
Microwave

**TRAK
MICROWAVE
CORPORATION**
5006 N. Coolidge Ave.
Tampa 3, Florida

**Specialists In Miniature
Microwave Energy Sources**

New Products

(Continued from page 118)

MICRO-POWER EMPLOYS MODULAR DESIGN IN ITS BWO POWER SUPPLIES



High performance electronically controlled power supplies for Backward Wave Oscillators are available from Micro-Power, Inc., Long Island City, N.Y., manufacturer of power supplies for microwave tubes.

The modular construction provides a flexible means for meeting the individual requirements for a wide range of tube types. Electrode supply modules are available with external DC-coupled rapid full-range electronic control for automatic system or equipment applications. Manually controlled modules are available for fixed operation.

The control signals may be fed through DC-coupled shaping networks for linearization of the frequency vs. voltage characteristics of the BWO. Complete tube protection is provided by current limiting, overload cut-out and time delay. Either terminal of the power supply can be grounded and, in addition, the supply is short-circuit protected.

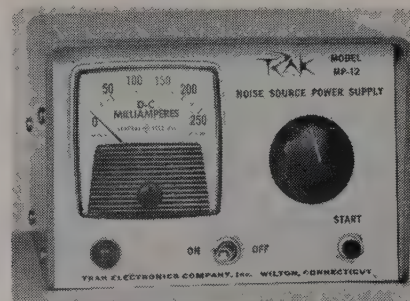
Semiconductor diodes and transistors are used to optimize reliability and provide small physical size.

Specifications include: .002 per cent line regulation; .005 per cent load regulation; .0001 per cent rms ripple for manually controlled electrode supplies; .001 per cent rms ripple for electronically controlled electrode supplies; regulated DC filament supply. Size: 5-1/4 inches high x 19 inches wide x 17 inches deep, standard rack mounted. These power supplies are available from stock.

Circle Reader Service Card 121

— m w j —

NOISE SOURCE POWER SUPPLY PROVIDES STARTING PULSE OF 2000 VOLTS



A tool to assist the electronic design engineer in testing microwave noise sources has been developed by Trak Elec-

tronics Company, Inc., Wilton, Conn.

Called the Noise Source Power Supply (Model MP-12) the 6 lb. portable unit provides a starting pulse of 2000 volts, with operating current variable by a single control over a 30 to 150 milliamperes range at operating voltages of 30 to 2000 volts.

The power supply accommodates miniature gas noise sources manufactured by Tucor, Inc., a Trak subsidiary, as well as almost conventional cold-start and hot cathode type noise sources. Simple connection of the Trak noise source power supply to the laboratory breadboard hook-up eliminates building "jerry-rigs" which normally have to be constructed to provide adequate striking voltage for microwave noise source experimentation and design work.

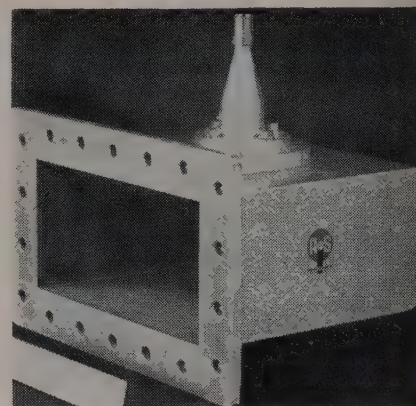
The portable unit measures 4 1/2 inches x 6 inches x 6 1/2 inches; it is also available in a rack-mounted version (Model MP-12R), measuring 3 1/2 inches x 19 inches x 5 1/2 inches. The equipment is available from stock and is priced at \$125.00.

On special order, solid state noise source modulators with synchronizing input suitable for radar system operation are available as part of a complete noise figure monitor.

Circle Reader Service Card 122

— m w j —

ANTENNA SYSTEMS OFFERS LINE OF WAVEGUIDE TO COAX TRANSITIONS



Antenna Systems, Inc., Hingham, Mass., offers a complete line of waveguide to coax transitions in all standard waveguide sizes from WR-430 through WR-2300.

They are recommended for average power to 10 kw, but units for higher powers are available on request. The VSWR is less than 1.25 over the entire waveguide band.

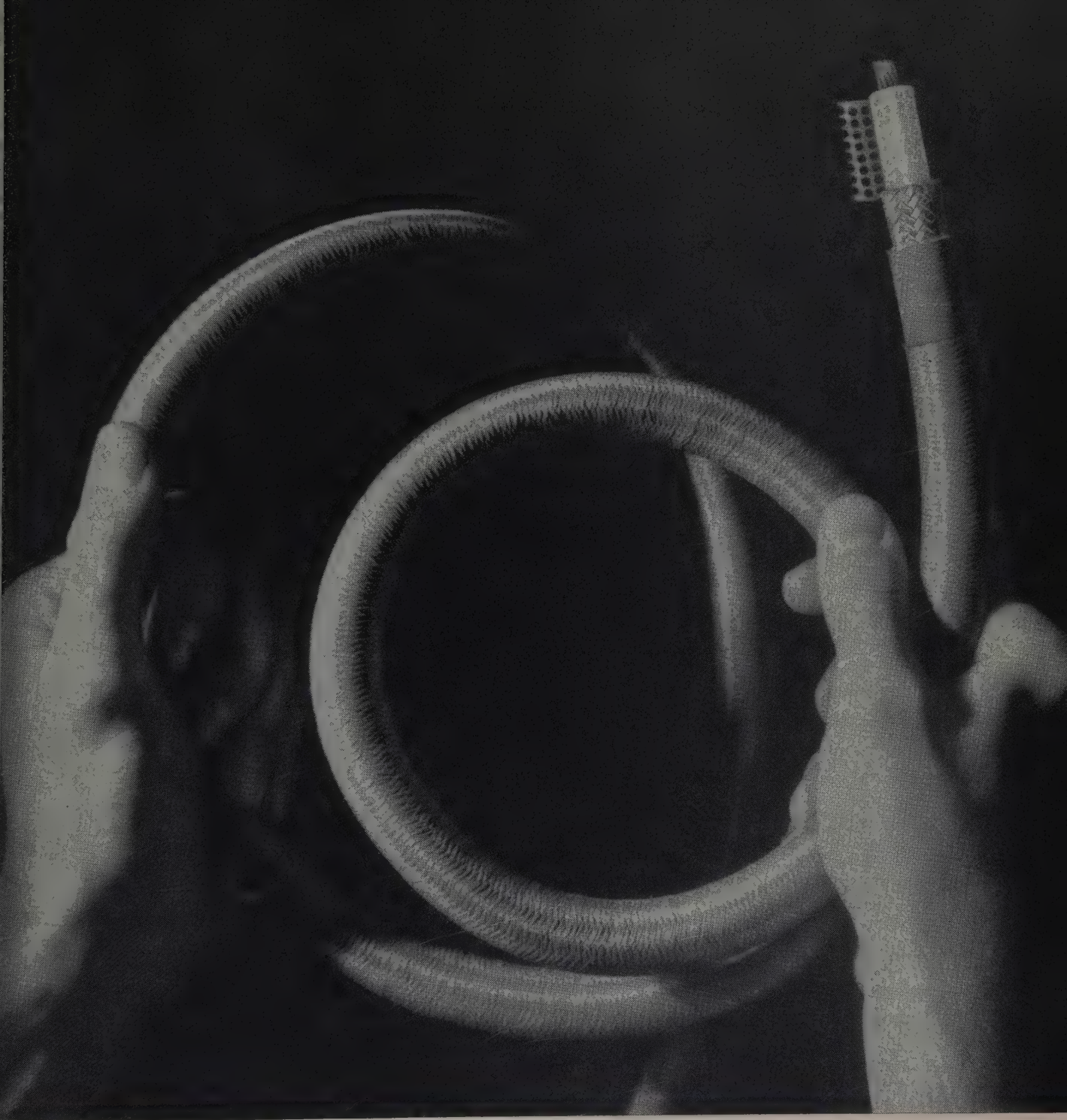
Standard units are pressurized on the coax side, but a pressurizing port on the waveguide can also be incorporated. Input sizes available are Type "N," 7/8 inch, 6-1/8 inches, and 9 inches.

Circle Reader Service Card 123

— m w j —

(Continued on page 122)

the microwave journal



Can high-power coaxial cable be really flexible?

Yes, if it's our new perforated Teflon® tape cable—type RG-281/U. Here's an extra-flexible, high-power coaxial cable originally developed for an Air Force electronic counter measures system.

Besides its flexibility, it offers many other advantages:

□ *Greater Thermal Stability* of this unique dielectric construction eliminates voids between cable and connector dielectrics; thus moisture condensation at dielectric interface is minimized.

□ *True Dimensional Concentricity*, impossible with semi-solid dielectrics employing filament construction, is achieved by perforated Teflon tape. Concentricity, even over small bending radii, is maintained because center conductor is continuously supported by dielectric. There are no filaments to slip and bunch under flexing.

□ *VSWR less than 1.2*. The perforated Teflon tape gives a *uniform distribution* of air spaces in the dielectric.

□ *Low Loss*—A dielectric constant of 1.55, compared to 2.0 for solid Teflon, assures improved power transmission.

Use Amphenol brand RG-281/U as a general purpose radio-frequency transmission line in applications involving high power, low loss, flexibility, high temperature, dimensional stability and exacting electrical characteristics.

Write today for Data Sheet to: FXR, 33 East Franklin Street, Danbury, Connecticut. ®Du Pont

FXR

THE RF PRODUCTS AND MICROWAVE DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION

Circle Reader Service Card 68

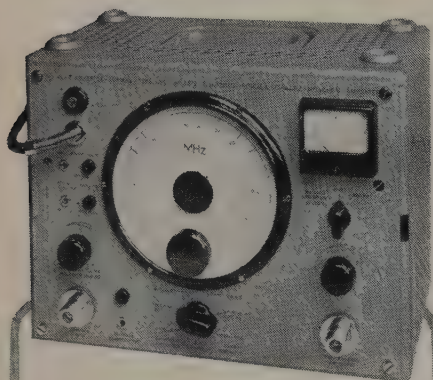
FIFTEEN IN ONE

TUNABLE

VHF AMPLIFIER

TYPE ASV

30 to 300 MC



A Measuring Instrument That Functions as:

- Receiver
- Frequency Meter
- Voltage Amplifier
- AM Modulator
- Indicating Amplifier
- Null Detector
- AM Demodulator
- FM Demodulator
- Power Amplifier
- VHF Signal Generator
- Buffer Amplifier
- Limiting Amplifier
- 1000-cps Generator
- Frequency Converter
- Harmonic Generator

Here is an ideal combination of fifteen instruments all in one. Its numerous applications, compactness and accuracy make it a basic tool in the VHF range. Combined with other VHF equipment, the Type ASV will extend their measuring ranges and possibilities. Because of its high versatility, the use of one or more of these Tunable VHF Amplifiers will be found highly effective in solving measuring problems at low cost.

WRITE FOR ADDITIONAL INFORMATION

ROHDE & SCHWARZ

111 Lexington Ave., Passaic, N. J.
PRescott 3-8010

New Products

(Continued from page 120)

ESCA ENTERS FIELD OF WAVEGUIDE FILTERS



Electronic Standards Corp. of America, Plainfield, N. J., announces that it has entered the field of waveguide filters. Using a not commonly applied design procedure, the company can manufacture to a wide variety of customer specifications very rapidly.

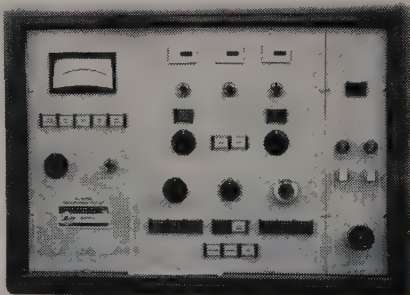
An example is a band branching filter in the C-band range. This is a combination of a bandpass and a band rejection filter, which is so arranged that the 3 db bandwidth of both filters coincide, the band which is rejected in the main arm being passed through the side arm. This results in a filter which has a VSWR of less than 1.3 over the whole frequency range of the waveguide, making it possible to put the filters in series branching certain bands consecutively off the main line.

Also, by terminating one of the two outputs, an absorption type band rejection filter can be assembled which has a low VSWR towards the load over the whole waveguide bandwidth. This might be of interest where devices are used, which are sensitive to loading condition, and their frequency might deviate from the pass or rejection band.

Circle Reader Service Card 124

— m w j —

KEARFOTT MARKETS ARMAMENT CONTROL SYSTEM CHECKOUT TEST SET



A remotely-operated armament control system checkout test set is being marketed by Kearfott Division of General Precision, Inc., Van Nuys, Cal., manufacturers of precision microwave components and test equipment.

With a single operator, the Ku-band test set performs aircraft flight-line and production line final integrated system tests quickly, accurately and economically. The

light, easily transportable console makes a semi-automatic checkout of a complete armament control system, simulating targets over a wide range of variables. The set acts as an absolute performance device, reading out the accuracy, availability and flight-line readiness of armament control system equipment.

Performance characteristics, such as operational range (transmitter power and receiver sensitivity), target discrimination and tracking, and range tracking, can be determined within narrow limits. In addition, the set tests radar receivers by operating as a signal generator when radar silence must be maintained.

Circle Reader Service Card 125

— m w j —

BROADBAND SPECTRUM ANALYZER USES LOW POWER FOR OPERATION



A Broadband Spectrum Analyzer to measure the power and coverage of radio transmitter jamming signals has been designed and produced by The Electronics Group of General Mills, Minneapolis, Minn.

The device uses a simple, precise technique for analyzing the average radio frequency power level and frequency distribution, requires low power for operation, is light in weight, and supplies data for evaluation at high speed. It can be used as airborne equipment or as ground support equipment.

In measuring average power, the total time-average power output of a broadband radio frequency signal source is determined by averaging the power over the entire frequency band of generation.

Using high-powered jammer transmitters, a sample of the radio-frequency energy is reduced by 40 decibels and delivered to the analyzer. This energy sample is further diminished within the analyzer by a broadband coaxial directional coupler where it is picked up by a crystal detector. The resulting diode current is shown on the panel-mounted power monitor meter, calibrated from 0 to 350 watts.

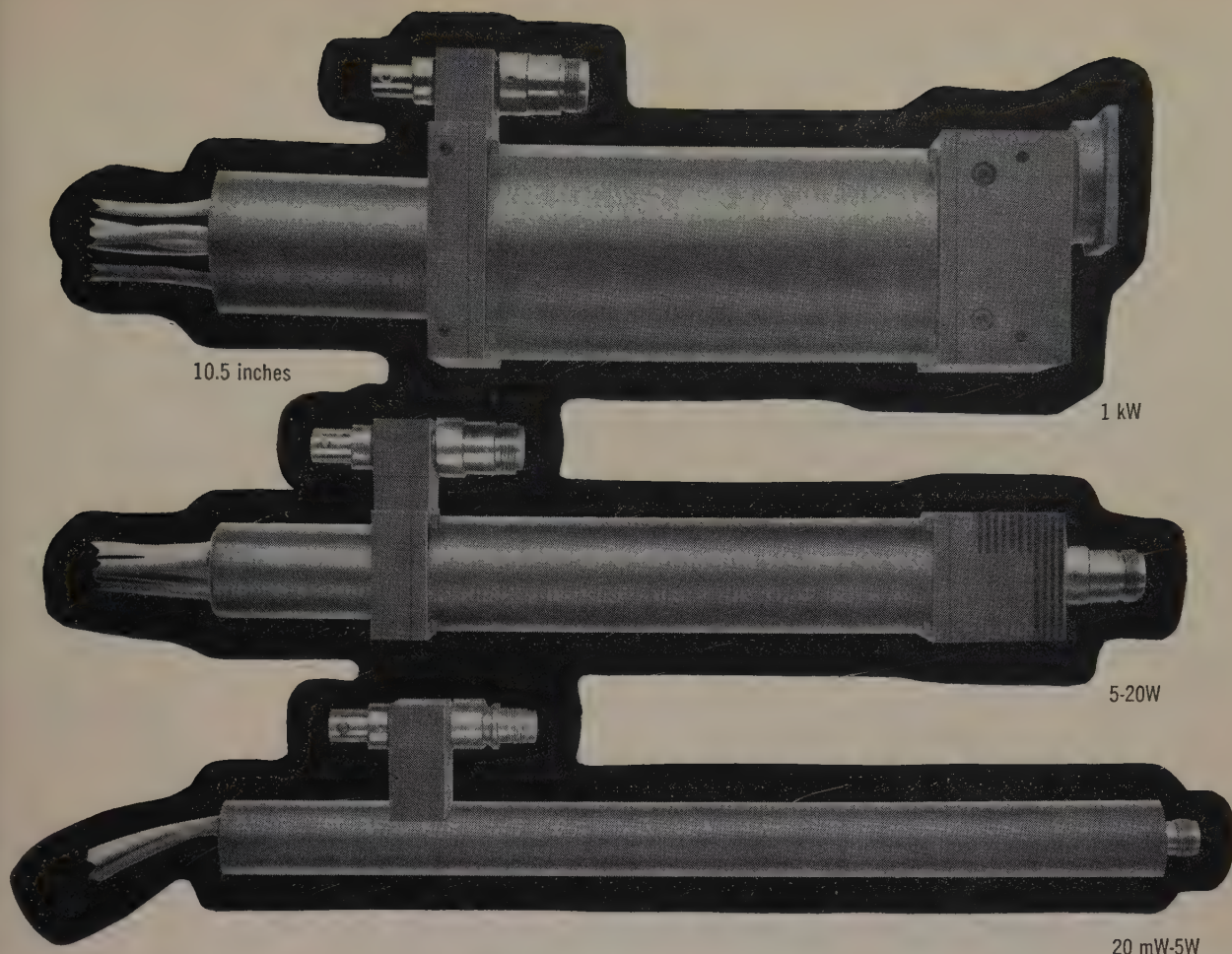
Power distribution measurements are made by sampling a portion of the jammer signal being fed to the antenna or dummy load, and passing this signal through a motor-driven tuned circuit of wide tuning range. Output from the tuned circuit is then envelope-detected, amplified and displayed on an external oscilloscope.

Circle Reader Service Card 126

— m w j —

(Continued on page 130)

the microwave journal



NEW LITTON TRAVELING WAVE TUBES

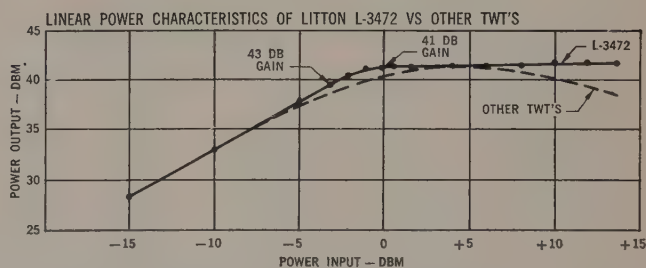
20 mW to 5.5 kW, 400 Mc to 11,000 Mc

Want high performance, high CW power and wide bandwidth from a compact, lightweight TWT? You get just that with the Litton Industries lightweight, undersized family of TWT's that are bigger and better in every other way. For instance, the L-3472 gives you 10 watts in a 12-inch, 2.5-pound package. The 2-watt L-3612 is only 11 inches long and weighs just 1.5 pounds.

Most of these tubes are PPM focused. Special helix design and fabrication techniques have raised the saturation gain to within three db of small signal gain. Can be supplied with small signal gains up to 60 db. Input and output circuits are coaxial, providing minimum frequency sensitivity. Bandwidth limited only by combined beam-circuit bandwidth. Optimum voltage for small signal operation same as for saturated operation. Helix isolated from tube body, permitting overload protection, helix modulation, and helix current monitoring.

Guaranteed to withstand Class II military environment. Applications include airborne ECM, power tube driver, radar target repeaters, and voice and data communications systems.

Contact us at San Carlos, California, for more information.



Tube Type Number	Frequency Range Megacycles	Power Output Minimum	Small Signal Gain Minimum	Duty Factor
L-3499	2000-4000	2 W	36 db	CW
L-3663	2000-4000	10 W	33 db	CW
L-3619	2000-4000	20 W	33 db	CW
L-3470	4000-8000	20 mW	36 db	CW
L-3711	4000-8000	1 W	36 db	CW
L-3471	4000-8000	2 W	36 db	CW
L-3657	4000-8000	10 W	33 db	CW
L-3658	4000-8000	20 W	33 db	CW
L-3611	7000-11000	20 mW	36 db	CW
L-3612	7000-11000	2 W	36 db	CW
L-3528	5000-11000	5 W	33 db	CW
L-3472	7000-11000	10 W	36 db	CW
L-3529	7000-11000	20 W	36 db	CW
L-3614	8000-11000	1 kW	36 db	.02
L-3497*	1240-1400	5.5 kW	40 db	.06
L-3674*	400- 450	5 kW	37 db	.06
L-3637*	5900-8400	200 mW	30 db	CW

*In Development



LITTON INDUSTRIES
Electron Tube Division

MICROWAVE TUBES AND DISPLAY DEVICES



expressway for automatic all-weather landings



The Steel Products
Engineering Division

Kelsey-Hayes is developing the radar antenna mounts for **Bell Aerosystem's** All-Weather Automatic Landing System. Designated AN/SPN-10 by the Navy, the system has been selected for use aboard the nuclear-powered aircraft carrier USS Enterprise and other large carriers.



Since 1914, Speco has been a vital force in the nation's aviation and defense programs . . . and since 1949, has provided radar componentry for Titan, Hawk, Nike-Hercules, Nike-Zeus and many other guidance systems. For further information, write Speco Division, Kelsey-Hayes Co., Springfield, Ohio.

KELSEY HAYES COMPANY

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

OPERATIONAL PLANTS: Detroit, Jackson and Romulus, Michigan; Los Angeles, California; Philadelphia, Pennsylvania; Springfield, Ohio; Utica, New York; Davenport, Iowa; Rockford, Illinois; Windsor and Woodstock, Ontario, Canada.





Microlab's 45,000 square foot plant was established in 1959 on 26 acres in Livingston, New Jersey. Plans for an additional building with 45,000 square feet are presently underway.

COMPANY PROFILE

MICROLAB

Livingston, New Jersey

Eleven years ago, Harry A. Augenblick recognized the need for a firm to specialize in the manufacture of microwave "hardware," the components vital to all microwave systems. He founded Microlab for the purpose, and today the company ranks as the largest firm specializing exclusively in the production of such components.

A unique program of simplification and standardization of components has been largely responsible for Microlab's rapid growth to a position as a major supplier to the microwave industry. Over 10,000 standard products are available for same day shipment "off the shelf." These proprietary designs account for the overwhelming majority of Microlab's dollar volume.

The concept of standardization was originated by Harry Augenblick early in Microlab's history. He reasoned that, if he could develop a series of standard units to satisfy the majority of applications, it would be possible to cut production costs substantially and shorten delivery time to customers. The line was developed by utilizing simplified designs and interchangeable parts.

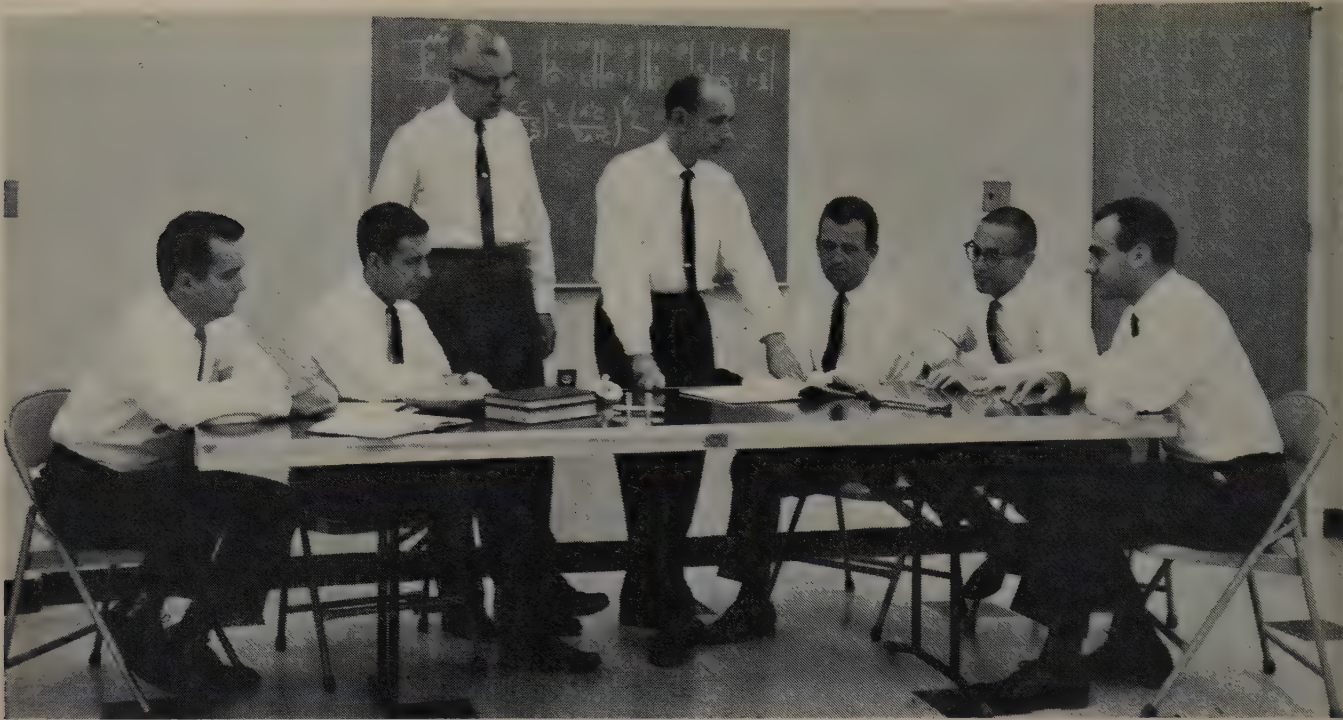
Standardization has provided a second important bene-

fit to Microlab customers, this in the area of specially engineered components. Adaptation of standard parts for use in custom components enables Microlab to reduce the amount of engineering time required and thus speed its delivery time for custom as well as standardized components.

Variations in electrical specification, in plating, mounting, connectors, and finishes are considered minor modifications which, at slight cost, are delivered with off-the-shelf speed. Major modifications in packaging for exceptional environmental conditions or requirements for sharper cutoff, lower VSWR or insertion loss, extreme accuracy of attenuation values, or high power application are designed around the existing, proven shelf products.

An M.I.T. graduate, Harry Augenblick was 23 years of age when he founded Microlab. He had been with I.T.T. Laboratories for three years as a research and design engineer.

For the first three years Microlab was virtually a one-man operation. Original production equipment consisted of a single lathe, and Harry Augenblick handled both



Discussing the theoretical foundation for an improved high pass filter are (left to right): Eugene May, Controller; Albert Sachs, Jr., vice-president and general manufacturing manager; Herb Engelmann, vice-president and technical director; John Vogler, general engineering manager; Harry Dolan, general marketing manager; Harry Augenblick, president; and Richard Hess, vice-president and planning director.

sales and production. His firm now occupies a new 45,000 square foot plant located on a 26-acre industrial tract in Livingston, New Jersey.

As the firm grew, the concept of standardization was put into practice. Engineering studies provided a selective choice of frequencies and led to the development of a line of low-pass filters, which provide maximum band pass characteristics coupled with maximum harmonic and noise suppression. Design and manufacture of machine parts were standardized to achieve maximum interchangeability.

Standardization became the guiding philosophy of Microlab and has been extended to the firm's entire line of products. For example, parts designed for a high pass filter are interchangeable with those used on a low pass filter, attenuator or crystal mixer. The line of proprietary products includes: fixed and turret attenuators, reactive and resistive dividers, high and low pass filters, terminations, crystal mounts, DC blocks and shorts, monitor tees, signal samplers, directional couplers, crystal mixers, and other coaxial components.

Each line was considered carefully before inclusion. Microlab's management group asked themselves three key questions before embarking on a new product line:

1. Can we make it?
2. Can we sell it competitively?
3. Does it lend itself to standardization?

The third question is, of course, the most vital. If the proposed product lends itself to standardization, Microlab feels certain that they can produce it competitively and win a share of the market by providing immediate delivery. Nor are these three key questions something filed away somewhere in the company archives. They are being considered almost daily as Microlab expands its product line thru its continuing development program. In recent months, for example, a new miniaturized direc-

tional coupler and a crystal mixer have been introduced. Scheduled new products this year include fixed-tuned and gang-tuned preselectors which have been uniquely designed to make standardization possible.

For the immediate future, Microlab plans to remain in the microwave field and to broaden its line of proprietary products. A number of components still untouched by standardization are being considered. Mr. Augenblick says, "By developing our own line of products utilizing our techniques of standardization, we hope



The Engineering Department, which occupies approximately 10,000 square feet of office space, is staffed by 25 graduate engineers headed up by the vice-president of Engineering, Herbert F. Engelmann, former national chairman of the IRE Professional Group on Microwave Theory and Techniques.

offer the widest possible selection of 'off-the-shelf' microwave components. Long term growth plans under study may involve expansion into infra-red and other high frequency activities."

A point of major emphasis at Microlab is the development of managerial talent. President Augenblick sees this as a growth function. Proper training gives the executive a wider horizontal base upon which to develop his career.

Management operations implement this policy. Two management committees guide the firm's operations, the Executive Committee and the Management Committee.

The Executive Committee is composed of Mr. Augenblick; Mr. Herbert F. Engelmann, V.P. and technical director; Mr. Richard C. Hess, V.P. and planning director; Mr. Albert Sachs, V.P. and general manufacturing manager; Mr. Eugene R. May, controller and general administrative manager; Mr. Harry C. Dolan, general marketing manager and Mr. John Vogler, general engineering manager. This group is responsible for long range planning, financial policy, and for development of new avenues of growth.

The Management Committee is made up of the heads of the various divisions and departments of the company. It is responsible for line functions in the day to day running of the company. It also assists and advises the Executive Committee in its long range planning, thus providing valuable aid and information to top management and valuable training for department heads as part of Harry Augenblick's policy of growth from within.

Four divisions and two staff advisory functions comprise the organizational skeleton reporting to the president: Engineering, Marketing, Manufacturing and Administration, plus a Planning office and Technical office.

Engineering

The Engineering Division is under the guidance of Mr. John Vogler, who directs a large staff of graduate engineers. This group received many patents in the microwave field.

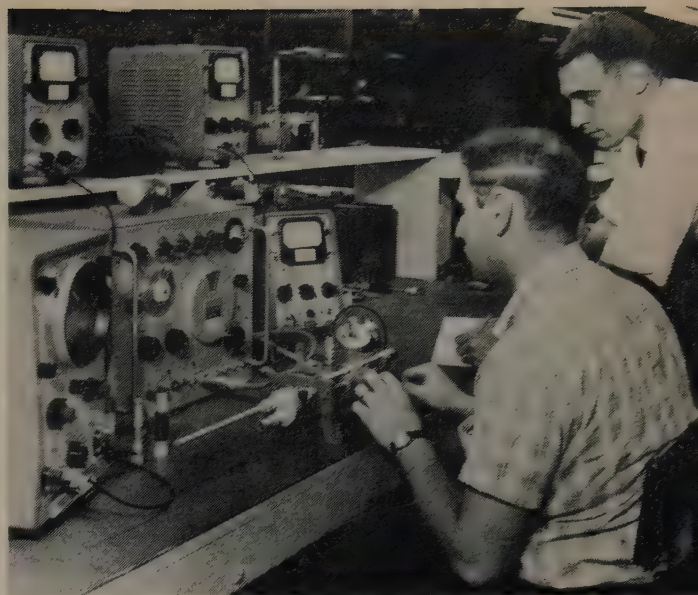
Engineers who are specialists in Microlab's product areas are constantly concerned with three major functions. These are improvement of current products, feasibility and design studies on potential new products, and the engineering and production supervision required to produce custom components.

A special project, for example, involving a filter for exceptionally high power application, would be under the supervision of a microwave engineer with mechanical engineering service support. Once studies were completed and specifications established, the filter would be pilot produced in the development laboratory's model shop under engineering supervision. It would then be tested and released for production.

In the case of orders for five pieces or less, the production of the order may be completed in the laboratory model shop. Larger orders are scheduled into the plant's production departments.

Production

Maintaining manufacturing flexibility in the face of rapid growth and keeping up the company's policy of immediate shipment from stock requires precision plan-



Shown being tested in the Engineering Lab is a new coaxial ring hybrid. In recent months, Microlab has introduced three new propriety product lines, including a new miniaturized directional coupler and a crystal mixer with optimum conversion efficiency.

ning. Production is directed by Mr. Albert Sachs, V.P. and general manufacturing manager. A constant check is made to assure that proper inventory levels are maintained on standard cataloged products. This provides flexibility for peak production periods, special orders and product qualifying runs. To prove out drawings, production capability and accumulative pre-production skills, new product qualifying runs have been adopted by Microlab as standard operating procedure.

Microlab manufactures almost all of the components used in its products, maintaining a totally integrated manufacturing operation. By manufacturing almost all components, Microlab gains optimum control of quality and delivery.

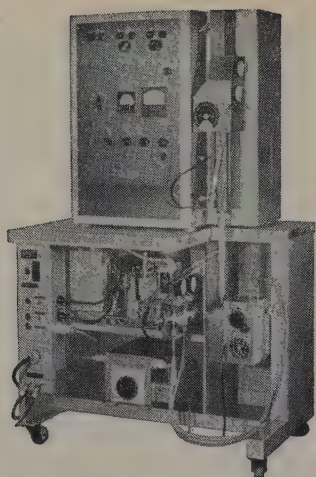
Marketing

The marketing function is headed by Mr. Harry C. Dolan, general marketing manager. His sales and customer service organization is geared to the firm's "off the shelf" delivery policy. A phone order, for example, is written up and an advance copy reaches the order processing department within minutes. If the order is for a standard component, the shipment may be packed and awaiting even before the paper work authorizing it has been completed.

The field sales force, mostly factory representatives, has been extended and consolidated in the past two years. Microlab has established distribution in 13 territories through sales representative firms. Application engineers back up this sales force. Sales department records show a roster of over 800 domestic customers. Foreign sales are handled through manufacturers representatives in England, France, Holland, Denmark and Australia.

Success of the "off the shelf" policy is shown by the firm's volume. Sales in the past 10 years have increased more than 50 per cent each year to the current estimated annual volume of \$3,000,000.

(Continued on page 128)



UNIQUE VERSATILE COMPLETE microwave dielectrometer

Measures dielectric constant and loss
over a wide temperature range
at 1, 3, and 8.5 kmc.

With a complete line of accessories the Central Research Laboratories Dielectrometer gives high accuracy and unequalled versatility.

Accessories now available: *Temperature Control Unit*. Enables dielectric properties of solids to be measured at any temperature between -30°C and $+500^{\circ}\text{C}$; liquid samples to $+150^{\circ}\text{C}$. Includes waveguide extension and sample holders for solids and liquids.

Room-Temperature Extension Sample-Holder. For measuring liquids or semi-solids at room temperature only.

Quarter-Wave Spacers. Accurately-cut, low-loss quarter wave spacers to make open-circuited measurements or gain greater sensitivity with thin samples.

For brochure giving details and specifications, write:

Central Research

laboratories, inc.

Dept. 203 — Red Wing, Minnesota

Circle Reader Service Card 72

MICROLAB

(Continued from page 127)

In order to provide for continued growth and greater customer service, Mr. George W. Marshall has been added to the staff as sales manager. He heads the outside sales department and is responsible for all direct customer contact.

Administration

The Administration Division, under the direction of Mr. May, provides the necessary controls and services to the company and its divisions that are most conveniently performed in a central division. The division contains the Finance Department, Industrial Relations Department, Plant Engineering, Management Engineering Department, and Quality Control Department.

Planning Office

Mr. Richard C. Hess, vice president and planning director, is responsible for the development of company long-range plans including the investigation of new areas of interest and fields of endeavor. Until recently Mr. Hess, an M.I.T. graduate, directed the marketing activities of Microlab.

Technical Office

A graduate of Lehigh and former national chairman of the IRE professional group on microwave theory and techniques, are some of the qualifications Mr. Herl Engelmann brings to his job of technical director. He is responsible for the technical guidance for the company in product development, and new areas of technical achievement.

Facilities

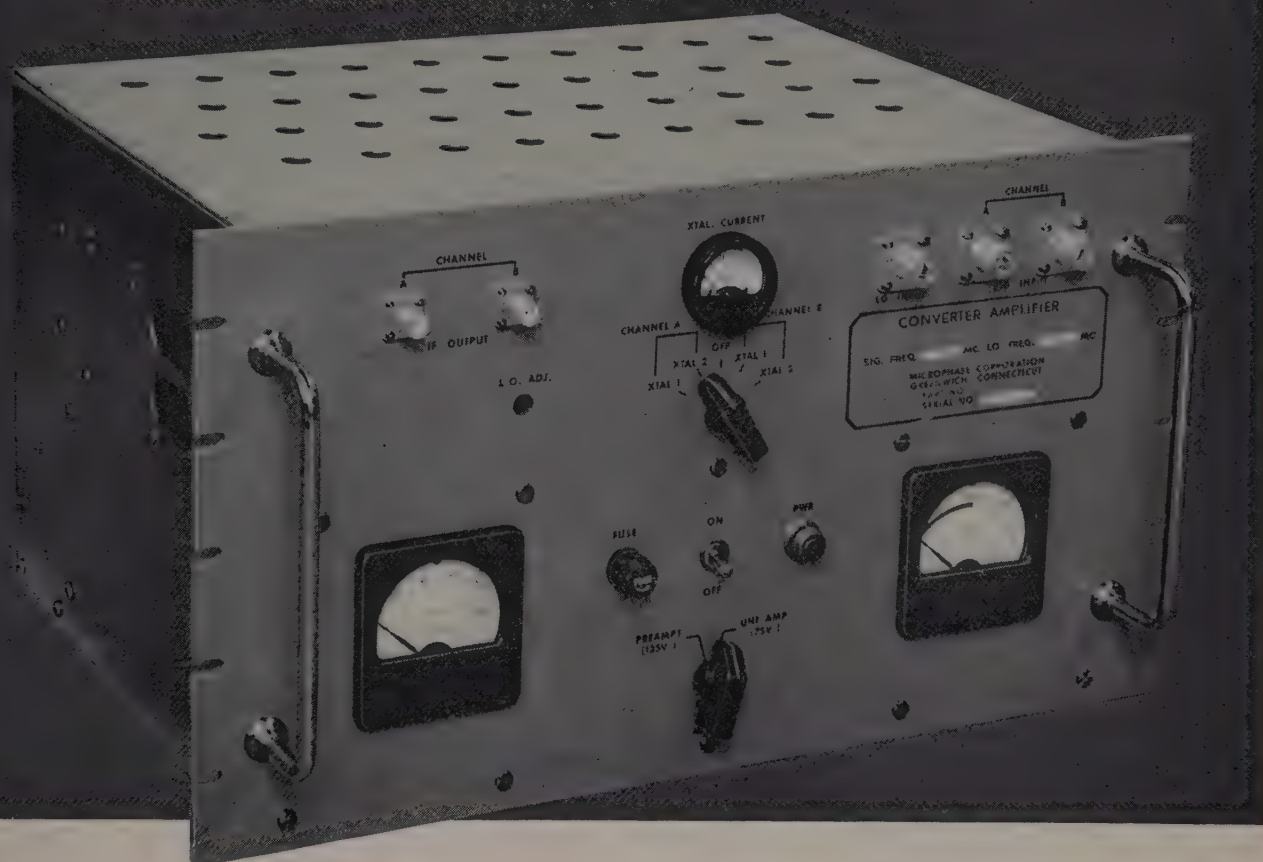
In 1959, Microlab built a new 15,000 square foot plant on a 26 acre tract in Livingston, New Jersey. In 1960 15,000 square feet were added, and a new 15,000 square foot addition has recently been completed. Plans are being drawn for another 45,000 square feet to be completed on the same tract in 1963. Facilities include advance development and design departments, separate model shop and testing laboratories, microwave test laboratory, mechanical inspection department, environmental test laboratory and qualification test department.

Future

President Augenblick sums up Microlab's plans for the future as follows: "We feel that our rapid growth proves the soundness of the concept of simplified standards and components. But there are still a number of microwave areas to which this standardization can be extended. Design studies are underway, and we plan to double our production facilities so as to be ready to produce these new products. Right now, Microlab is the leading supplier of coaxial components. We are working to become the world's leading supplier of microwave components. For the future, we are studying possible expansion into other high frequency fields."

the microwave journal

MICROPHASE CAPABILITY extends from state-of-the-art individual components to COMPLEX INTEGRATED MICROWAVE ASSEMBLIES AND INSTRUMENTS



This **dual-channel receiver** covers the 1700-2400 mc range and has a 30 mc IF output. The circuitry includes tunable preselectors, balanced mixers, and low-noise IF preamplifiers. In this instrument, the local-oscillator injection is at $\frac{1}{4}$ the frequency required at the mixers. Both mixers are driven by LO energy that is internally amplified and multiplied; this assures phase coherence between channels. All operating voltages are derived from internal regulated power supplies.

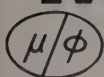
SPECIFICATIONS

(Each Channel Typical)

Signal Band (tunable)	1700-2400 mc
RF Bandwidth	10 mc
Image Rejection	60 db
LO Input Band	410-600 mc
IF	30 mc
Overall Noise Figure (including Preselector)	9.5 db
Overall Gain (RF to IF)	30 db

MICROPHASE CORPORATION

Box 1166 Greenwich, Connecticut NO 1-6200 / WE 9-9190 TWX GNWICH 759
R & D Facilities in Cos Cob, Connecticut



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For your micro-wave tower requirements, get the advantages of advanced design, superior workmanship, competent engineering assistance, and complete erection service.

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Peoria, Illinois

"Pioneer Manufacturers of
Towers of All Kinds"

New Products

(Continued from page 122)

STEWART BWO'S FEATURE INTEGRAL PERMANENT-MAGNET FOCUSING



Stewart Engineering Company, Santa Cruz, Cal., announces the introduction of two new microwave tubes. The backward-wave oscillators, of identical exterior appearance, feature integral permanent-magnet focusing, with the same reliable helix-type oscillator design utilized in the solenoid tubes to date.

The tubes are the first in a line of permanent-magnet focused backward-wave oscillators from 1 to 40 Gc. Stewart BWO's typically have a life of 5000 hours with no deterioration in performance.

The backward-wave oscillators are both in the X-band, available either with type 'N' or waveguide-adaptor termination at the end of RG55U coax cable. Significant advantages of these wide-band voltage tunable devices include low cathode current, more uniform rf power over the band, and two control electrodes.

The control grid makes possible power cutoff with low negative grid voltage, and the anode is usually employed in leveler circuits to provide ultra flat power output characteristics. Since all voltages are isolated from both tube housing and the rf output terminal, packaging problems are greatly simplified. Thus, the tube and output connector can be grounded regardless of power supply configuration.

Circle Reader Service Card 127

— m w j —

ION PUMP USES ELECTRO- CHEMICAL MEANS FOR ULTRA- HIGH VACUUMS

Amperex Electronic Corp., Hicksville, L.I., N.Y., announces the Titanium Ion Pump Type TP101, an inexpensive, disposable, vacuum tube-like device which utilizes a combination of electrical and chemical means to obtain quickly high vacuums in excess of 10^{-9} mm of mercury.

The unit is designed for evacuating electron tubes, external anode transmitting tubes, magnetrons, klystrons or other vacuum devices of comparable volume.

The tube incorporates two cathodes of the inverted V type on each side of the anode which consists of a square loop of tungsten wire. One of the cathodes is a single loop of tungsten wire; the other cathode is similar but is also wound with a titanium wire. The latter cathode serves to evaporate titanium and also provide the

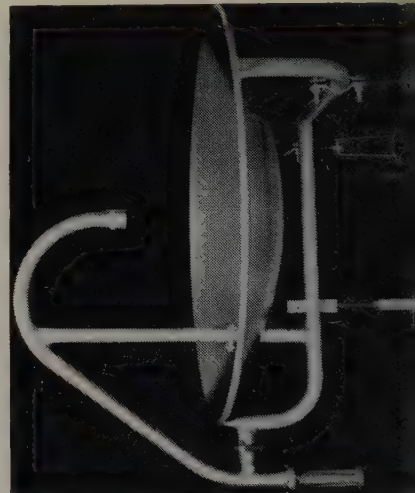
necessary negative potential conditions in the tube.

In essence, the Ion Pump operates on the Penning gauge principle combined with gettering action based upon slow evaporation of titanium. Available in sample quantities at \$15 per unit, the Ampere Titanium Ion Pump is intended to be a disposable unit. Its high capacity and high pumping speed markedly reduce time at expensive pumping stations.

Circle Reader Service Card 128

— m w j —

MARK RECEIVES PATENT NUMBER ON CIRCULAR WAVEGUIDE FEED



Mark Products Co., Skokie, Ill., received patent number 2,996,714 on their circular waveguide feed recently. The circular waveguide feed, employing a rectangular to circular waveguide transition section 8 inches long, allows a man to adjust polarization a full 360 degrees in the field simply by rotating the transition section.

The circular feed is used on Mark 6 to 8 gc, 4, 6, 8, and 10 foot parabolas. A dual polarized adapter is available for converting a single polarized feed simply by replacing the transition section.

The conversion may be made any time system expansion is required in the field. The change may be made in about ten minutes.

In addition to the 6—8 gc. line MARK manufactures parabolas for 450, 900, 2000, and 12,500 Mcs bands.

Circle Reader Service Card 129

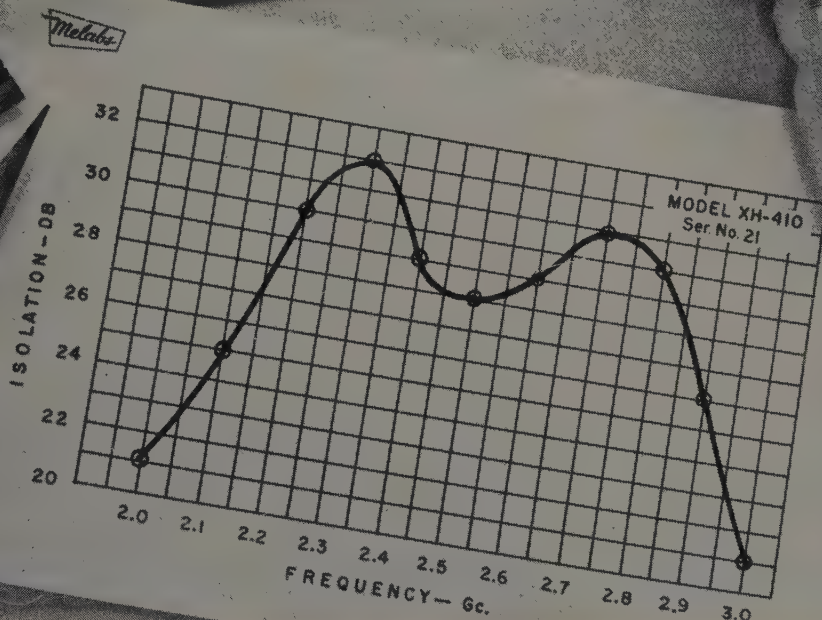
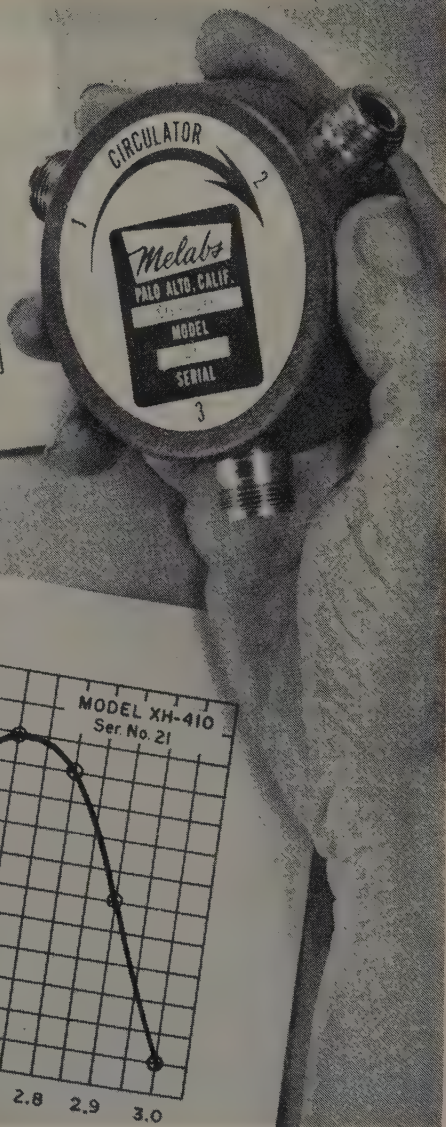
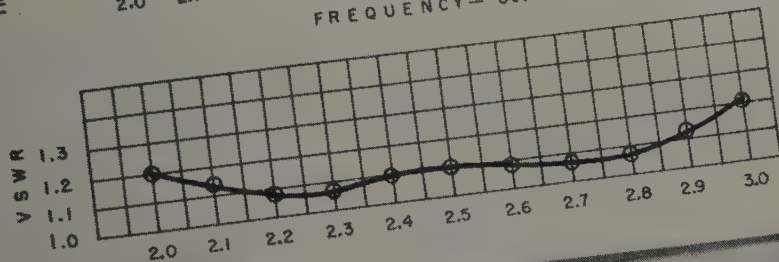
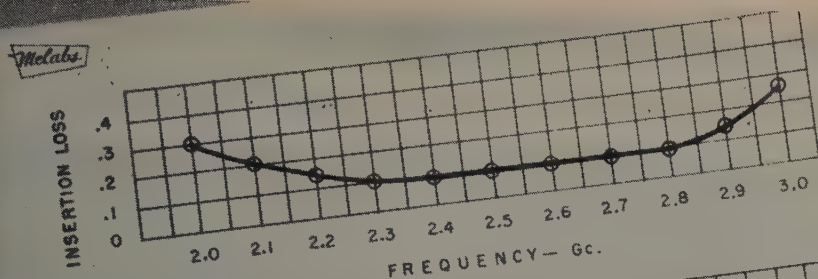
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HIGH-TEMPERATURE ARTIFICIAL DIELECTRIC MATERIALS AVAILABLE

Custom Materials, Inc., Chelmsford, Mass., announces the availability of high temperature (500°F continuous operation) artificial dielectric materials under the name of Custom High-K 707. The range of dielectric constants is from 3 to 18.

The advantage of using an organic based dielectric material over the presently used

(Continued on page 132)



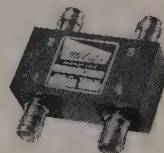
NEW... VERY BROADBAND low loss COAXIAL CIRCULATORS

Now available... an entirely new series of coaxial Y circulators providing complete overlapping coverage of "S" and "C" bands. (Continuous 1.7 to 8.0 Gc.)

These very broadband, low loss circulators are light in weight and comparable in physical size to 10% bandwidth units. Typical measured performance is shown on curves above.

FREQUENCY RANGE:	Model	
	XH-409	1.7-2.3 Gc
	XH-410	2.0-3.0 Gc
	XH-411	2.5-3.5 Gc
	XH-412	3.0-4.0 Gc
	XH-420	3.5-5.0 Gc
	XH-421	4.5-6.5 Gc
	XH-422	6.0-8.0 Gc

Inquiries are invited on a completely new line of high average power coaxial circulators and isolators. Power capability is 400 watts average without cooling at S and C bands.



OTHER IMPORTANT NEW MELABS CIRCULATORS

Complete line, 4-port circulators, 800 mc to 8 Gc range. Illustrated: XH-415 ultra-miniature, 5.4-5.9 Gc. Insertion loss, typical 0.15 db at center, maximum 0.3 db at ends. 5 ounces—stable to 105°C.



3300 HILLVIEW AVENUE / STANFORD INDUSTRIAL PARK / PALO ALTO, CALIFORNIA
TELEPHONE: DA 6-9500. AREA CODE: 415; TWX: PAL AL 138

Employment opportunities at Melabs are exceptional for ambitious engineers and physicists; write in confidence.
AN EQUAL OPPORTUNITY EMPLOYER

DEPT. B5

New Products

(Continued from page 130)

ceramics are: extremely low moisture absorption, reproducibility, ease of machining to shape, and ease of casting or molding to shape where quantities and complex designs prove economical.

Custom High-K 707 is stocked in dielectrics of 6, 9 and 12 as rods, bars and sheets. Experience to date has proven that Custom High-K 707 can be manufactured for the customer to a dielectric constant tolerance of ± 1 at microwave frequencies.

Custom High-K 707 is available as a casting compound for "do it yourselfers" in 1 lb. containers. Due to the special handling and packing required for small quantities lots, the cost is \$18 a pound.

Circle Reader Service Card 130

— m w j —

NEW DESIGN SPURS COOK TO DEVELOP MINIATURE WAVEGUIDE SWITCH

A new approach to the internal choke design of a waveguide switch has enabled NRK Microwave Division of Cook Electric Co., Chicago, Ill., to develop a high power miniature waveguide switch which is considerably smaller in size yet comparable in performance to competitive switches of conventional design.

NRK Microwave is marketing switches of this design to cover the frequency range from 5.85 to 18 Gc. The X-band switch for use with RG 67/U guide has a maximum VSWR of 1.10:1 minimum isolation

of 50 db and 0.10 db insertion loss and 250 kw peak power handling capability at one atmosphere from 8.5 to 9.6 Gc.

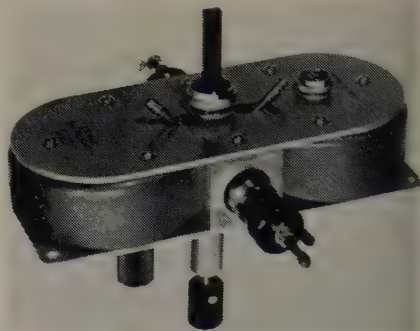


The RG 67/U switch can be pressurized to 45 psig and is driven by a "fail safe" solenoid drive to operate from either 28 VDC or 110 VAC. At 28 VDC the maximum switching current is 1 amp.; holding current is 1/2 amp. Provision for remote rotor position indicators is provided on all switches if required.

Circle Reader Service Card 131

— m w j —

THREE FLOATING DRIFT TUBE OSCILLATORS AVAILABLE FROM LITTON



Three floating drift tube klystron oscillators, developed by Elliott-Litton, Ltd., are available through Litton Industries' Electron Tube Division, San Carlos, Cal.

The tunable high power 4 m/m klystrons are water-cooled harmonic generators operating in the frequency range 68 to 80 kMc/s with a tuning range ± 750 Mc/s. Average life is estimated at 500 hours minimum.

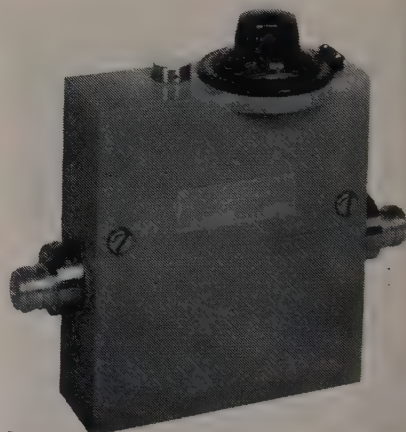
The L-3689 provides a power output of 500 mW average; the L-3690 operates at 100 mW minimum; and the L-3691 supplies 100 mW average power.

For all three tube types, both bunching and harmonic cavities are tunable, enabling the power output to be optimized at any operating frequency within the covered band. A small amount of power may be coupled out of the bunching cavity to assist in tuner adjustment and to allow the frequency measurement of the 4 m/m signal without a 4 m/m wavemeter. Two additional fixed tuned tubes, the L-3638 and L-3639, also are available in the 4 m/m range.

Circle Reader Service Card 132

— m w j —

WAVELINE COAXIAL BANDPASS FILTERS COVER 0.9-6.0 KMC FREQUENCY RANGE



Waveline, Inc., Caldwell, N.J., announces the development of a series of wide tuning range coaxial bandpass filters covering the frequency range of 0.9 to 6.0 kMc. Seven basic models provide selective tuning over an extremely wide range of frequency through 3 cavity gang-tuned structures.

(Continued on page 134)

the microwave journal

PRECISION WAVEGUIDE BENDING

TO YOUR SPECIFICATIONS

Bends, Twists, Offsets, Coils,
Transitions, Fabrications and
complete assemblies to your prints.

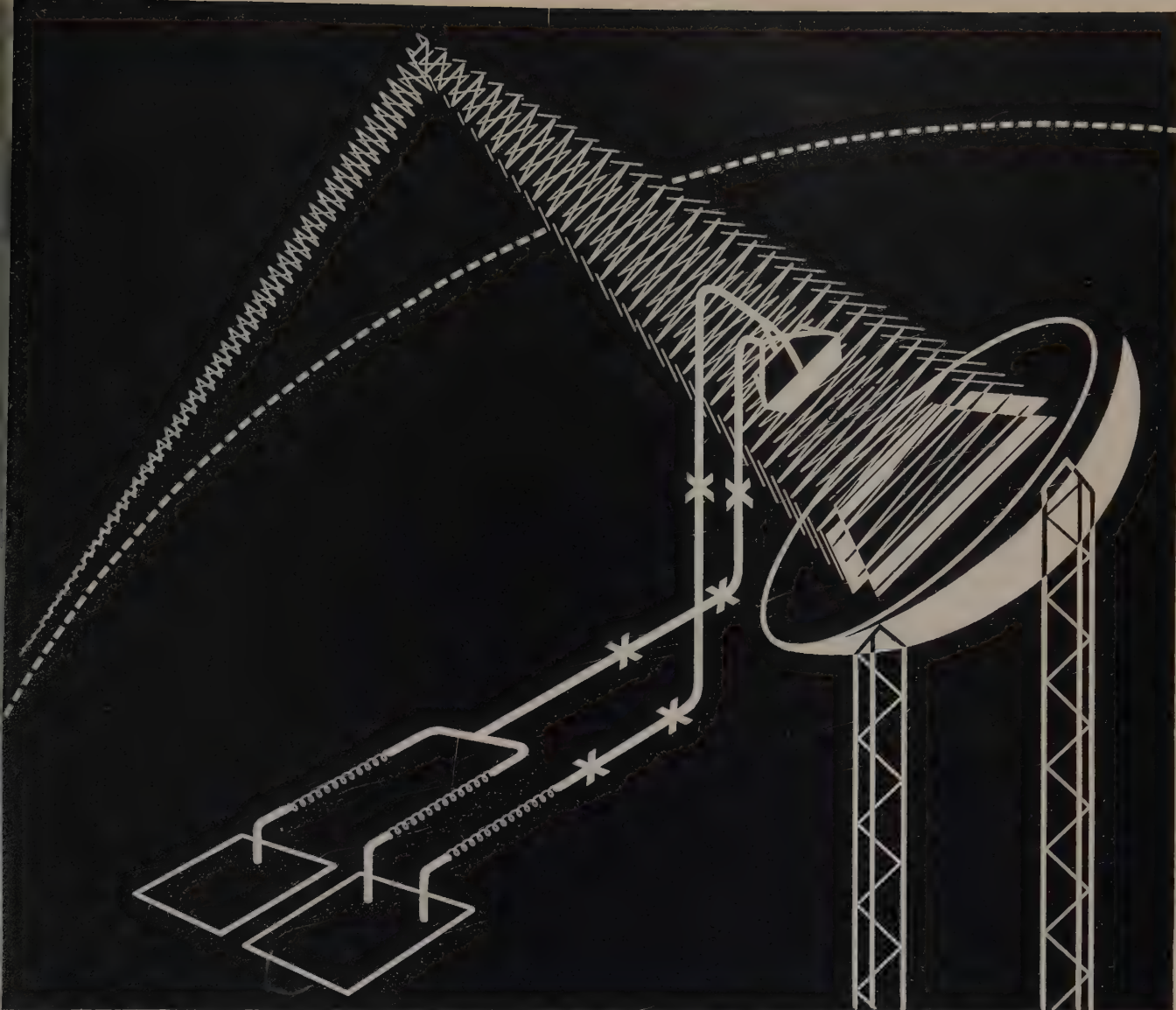
Specialty

AUTOMATIC MACHINE

C O R P O R A T I O N

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TEL. BRowning 2-0800

Circle Reader Service Card 76



Beyond the horizon

From diplexer to antenna, I-T-E engineers are specialists in tropospheric scatter communication systems built to the most exacting requirements yet demanded by the state of the art. These systems assure reliable "beyond-the-horizon" communication for commercial and military services. Diplexer and attendant filters, large waveguide components, articulators, feedhorn and antenna are assembled and tested to provide a combination of components in a system with the minimum cumulative VSWR.

An example of I-T-E's attention to detail is the development of articulators that provide ample flexibility for expansion of the waveguide run and positioning of the feedhorn without a change in VSWR value. Accurately fabricated large waveguide,

from WR430 to WR2300, assure greatest power handling capability at a minimum VSWR. And I-T-E's Twin-Tee* dual-polarized feedhorns and antennas complete the many troposcatter systems now in service.

In the broad capabilities of I-T-E's Special Products Division are accomplishments in other related fields. Developments in resonant rings and comparable test devices are just a few of the examples of complex I-T-E microwave systems in large waveguide. Information on this specialized service is available by calling GARfield 6-5700 or by writing I-T-E Circuit Breaker Company, Special Products Division, Department MJ, 601 East Erie Avenue, Philadelphia 34, Pennsylvania.

*Trade Mark



I-T-E CIRCUIT BREAKER COMPANY
SPECIAL PRODUCTS DIVISION

New Products

(Continued from page 132)

To illustrate the degree of performance achieved in any of the standard units the characteristics of the model covering the 1.7 to 2.4 kMc are as follows: waveguide part number 90164; bandpass filter, 3 cavity; type N input & output connectors; single tuning control through 40 turn calibrated dial; tuning range: 1.7 to 2.4 kMc; nominal 3 db bandwidth: 12 Mc; rejection at $F_0 \pm 40$ Mc: 40 db minimum; insertion loss: 1.5 db maximum; and input VSWR: 1.50 maximum.

Standard designs are also available for various degrees of rejection through the use of 2, 3, and 4 cavity individual or gang-tuned devices. Special system application requirements can be satisfied through minor modifications of the basic standard designs. Complex design objectives can be considered.

Circle Reader Service Card 133

— m w j —

TACO INTRODUCES RIGID COAXIAL TRANSMISSION LINE HARDWARE

The Technical Appliance Corp., Sherburne, N.Y., manufacturers of the TACO line of antennas and antenna systems announces the introduction of a complete line of straight sections, connectors, elbows, and all necessary hardware and accessories for the installation of a Rigid Coaxial Line System. Rigid line is suitable for radio frequency, high power sig-

nals found in radio and television transmission, and radar applications.

Taco rigid transmission line is available in all sizes with 50 ohm characteristic impedance, and in the 6-1/8 inch size with 75 ohm impedance to match the universally accepted terminal and feed impedance characteristics. Taco offers a choice of either copper or aluminum outer conductors. Copper is recommended for long runs because of superior conductivity, particularly at higher frequencies, to minimize attenuation. Aluminum is the choice when light-weight installations are desired.

TACO rigid line can be pressurized and dehydrated to eliminate moisture accumulation that could lead to changes in impedance or short circuits within the line.

Circle Reader Service Card 134

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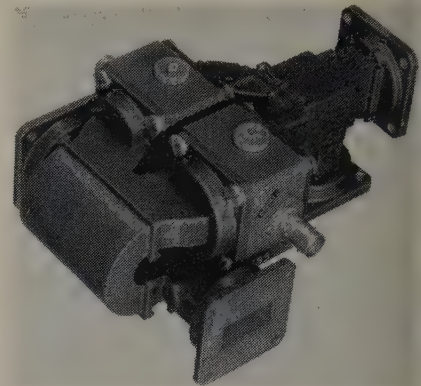
VARIAN SINGLE SIDEBAND MODULATORS FEATURE LOW CONVERSION LOSS

Single sideband modulators are available in the range from C- to Ku-bands from the Radiation Division of Varian Associates, Palo Alto, Cal.

The package consists of two Varian Orthomode® mixers and waveguide components which produce upper and lower sidebands at separate ports using the technique of phase cancellation between outputs of two double sideband modulators.

The compact units feature lower conversion loss, maximum suppression of the carrier frequency and unwanted sideband

in the output, together with high modulating frequencies. Typical figures are: conversion loss 10 db; maximum carrier input power 600 mw, carrier and unwanted sideband suppression 20 db below desired sideband; harmonic sidebands 15 db below desired sideband.

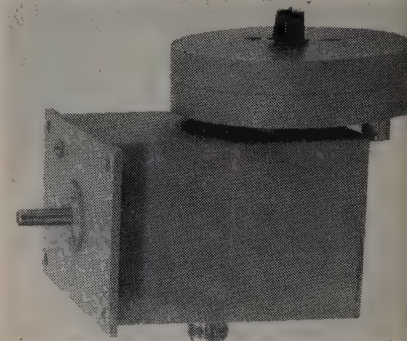


Modulation frequencies from a few kc extend beyond 120 Mc for standard units, and modified units may be used up to 3 Gc. Frequency ranges for these single sideband generators are: V-8370, 3.95 to 5.85 Gc; V-8371, 5.85 to 7.1 Gc; V-8372, 7.0 to 8.0 Gc; V-8373, 7.5 to 8.5 Gc; V-8374, 8.5 to 9.6 Gc; V-8375, 12.9 to 13.7 Gc. Delivery time is 60-90 days. Price on request; varies according to specifications.

Circle Reader Service Card 135

— m w j —

LOW NOISE MICROWAVE RECEIVER FRONT ENDS AVAILABLE IN L, S, AND C-BANDS



Frequency Engineering Laboratories, Asbury Park, N.J., introduces a line of low noise microwave receiver front ends consisting of tunable preselectors and coaxial balanced mixers.

The units are available in L, S, and C-Bands with a noise figure of 7.5 db maximum measured with a 1.5 db IF amplifier including the insertion loss of the preselector. The preselector is gang-tuned over a range of 10 per cent. The mixers are coaxial ring hybrids with integral holders for the mixer diodes. Both the preselector and mixer are designed as an integrated package.

S-Band unit specifications are as follows: bandwidth at 3 db point—8 Mc; bandwidth at 60 db point—120 Mc; connectors—Type N (RF input and output).

Circle Reader Service Card 136

— m w j —

(Continued on page 136)

the microwave journal

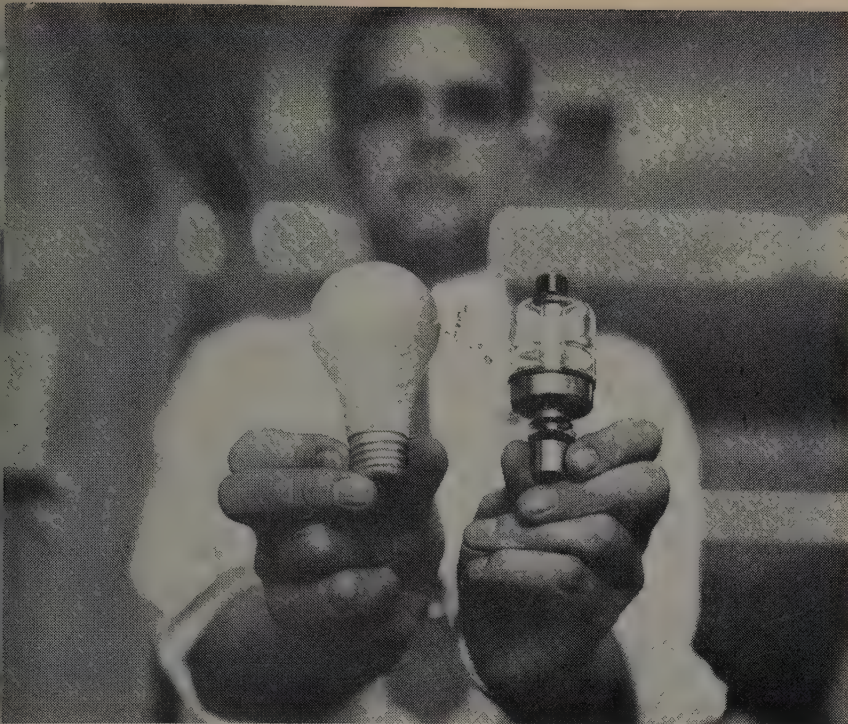
For the answers to problems in the design, fabrication, and installation of antenna systems in the fields of scatter communications, missile tracking, space tracking, radar and surveillance, radio astronomy and special antenna products...

ASK ASI

FOR FULL INFORMATION WRITE:

ANTENNA SYSTEMS INC.

HINGHAM, MASSACHUSETTS



WHAT'S THE DIFFERENCE BETWEEN A TR TUBE AND A LIGHT BULB?

Superficially, there isn't much difference at all. Both are combinations of glass, metal and wire. But their function is mighty different, and construction techniques are worlds apart.

We can't describe the details of light-bulb making, but TR tube making we do know, and it is a most exacting science. Twenty-three separate steps can be counted in the making of an

assembly-line type of Tucor TR tube, not to mention one of the special-purpose types of which we make many.

The skills involved are those of designers steeped in TR, ATR and Duplexer tube techniques... glass blowers who are masters of their craft... assemblers and testing engineers who are more specialized, perhaps, than any others in the electronics field.

The equipment for manufacturing Tucor TR tubes consists not only of elaborate standard devices, but of special and exclusive Tucor equipment to obtain and maintain the ultimate in purity of the inert gas fill.

These processes give Tucor precision TR tubes an added factor of reliability, life, and power handling ability. They are the reason that Tucor TR tubes live and live and live, and still perform.

Below are some typical data on representative Tucor TR tubes. More information on TR, ATR and Duplexer tubes is contained in Tucor Bulletin T-1. Just write for it.



TUCOR INC.

59 Danbury Road (Route 7)
Wilton, Connecticut

TR TUBES

Tube Designation	Type	Circuit	Recovery Time/3 db	Power Average	Power Peak	Frequency	Remarks
T48V1	Ring	7/8" coax	25 μ sec	200 w	400 w	275-600 mc	B, D
T48V3	Ring	7/8" coax	100 μ sec	600 w	10 kw	96-160 mc	B, D
T48V4	Plug-in	7/8" coax	100 μ sec	20 w	10 kw	200-600 mc	B, C
T48U1	Ring	7/8" coax	100 μ sec	400 w	10 kw	275-600 mc	B, D
T48U3	Folded Cylinder	3 1/8" coax/wg	80 μ sec	20 kw	2 mw	400-800 mc	A, D
T48U4	Folded Cylinder	6 1/8" coax/wg	100 μ sec	10 kw	1 mw	400-600 mc	B, D
T48U5	Folded Cylinder	6 1/8" coax/wg	320 μ sec	10 kw	2 mw	200-600 mc	B, D
T48U6	Folded Cylinder	6 1/8" coax/wg	160 μ sec	20 kw	5 mw	200-800 mc	B, D
T48U7	Folded Cylinder	6 1/8" coax/wg	160 μ sec	10 kw	2 mw	200-800 mc	B, D
T48U8	Folded Cylinder	6 1/8" coax/wg	1500 μ sec	4 kw	.5 mw	40-80 mc	B, D
T48U9	Plug-in	1 5/8" coax	150 μ sec	.2 kw	10 kw	300-600 mc	B, D, F
T48U10	Plug-in	3 1/8" coax	200 μ sec	.2 kw	20 kw	200-600 mc	B, D, F
T48U12	Folded Cylinder	6 1/8" coax/wg	150 μ sec	50 kw	10 mw	200-800 mc	A, D, E
T48U13	Folded Cylinder	6 1/8" coax/wg		10 kw	2 mw	400-800 mc	A, D
T48U14	Plug-in	3 1/8" coax	2500 μ sec (100)	5 kw	5 mw	400-600 mc	B, D, F
T48U15	Folded Cylinder	6 1/8" coax/wg	160 μ sec	50 kw	10 mw	200-800 mc	A, D, E
T48U16	Flange Plug-in	3 1/8" coax	2500 μ sec (100)	5 kw	5 mw	400-600 mc	B, D, F
T48U17	Flange Plug-in	3 1/8" coax	2500 μ sec (100)	5 kw	5 mw	400-600 mc	B, D, E, F

A — Quartz B — Glass C — Electronic Primed D — Radioactive Primed E — Uranium Getter F — Recovery Voltage

New Products

(Continued from page 134)

RYCOM VOLTMETER EMPLOYS HETERODYNE PRINCIPLE WITH BALANCED MODULATION



Rycom Instruments, Raytown, Mo., announces the release of its newest frequency selective voltmeter—Model 2173A.

The Model 2173A Frequency Selective Voltmeter is a highly selective measuring instrument employing the heterodyne principle with balanced modulation. It offers a fast and accurate means of making amplitude measurements throughout the frequency spectrum of 3.0 kilocycles to 2.0 megacycles.

The instrument uses highly selective crystal filters to achieve the resolution necessary for amplitude measurements of microwave subcarrier, wire line communi-

cations, and subcarrier telemetering systems. The Model 2173A is available with a narrow crystal filter (250 cycle) for amplitude measurements, and a wide crystal filter (2800 cycle) with demodulator for monitoring single side band speech or tone signals.

Its features include a gear-driven dial mechanism, balanced modulator and associated circuits, a high degree of accuracy in measurements from bridging circuit inputs, a tuning range of 3.0 kc to 2.0 Mc. with metering circuits for indicating levels from a -80 dbm to +32 dbm with accuracies of ± 1 db. Also provided is an internal speaker and headset jack for aural monitoring of signals. An internal oscillator and associated circuit is provided for a fast and accurate means of making amplitude calibration.

Circle Reader Service Card 137

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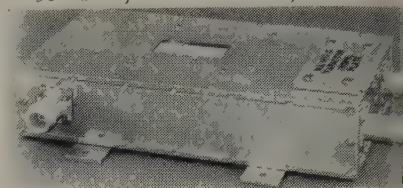
S-BAND MULTIPLIER ALSO OPERATES AS DIPLEXER

A microwave multiplier that includes the additional feature of diplexer operation has been announced by Telonic Engineering Corp., Laguna Beach, Cal.

Designed for S-band applications, the multiplier, model PM 1030/1090, provides

conversion from 257.5 Mc to 1030 Mc with less than 12 db loss in conversion. The pass bandwidth of the multiplier exceeds 8 Mcs for each channel and operates with over 1 watt input at 257.5 Mc.

As a diplexer the unit has a minimum -30 db adjacent channel rejection.



The unit is basically a varactor quadrupler that will accept 257.5 Mc and 1030 Mc inputs simultaneously, and provide output of 1030 and 1090 Mc. It is enclosed in a mil-slotted aluminum case to provide excellent rigidity and isolation. The entire unit measures 6-7/8 inches x 3-1/2 inches x 1-1/2 inches and weighs less than two pounds. Any of the common connector types can be provided.

Developed for use with microwave systems for applications involving simultaneous receiving and transmitting at the 1030 Mc and 1090 Mc frequencies, the new unit may also be ordered with any center frequency from 10 to 2500 Mc for special applications.

Circle Reader Service Card 138

— m w j —

FOUR CALIBRATED VARIABLE ATTENUATORS AVAILABLE FROM MICROWAVE ASSOCIATES

Microwave Associates, Inc., Burlington, Mass., announces the availability of four Calibrated Variable Attenuators in two type styles for power level adjustment of microwave equipment and laboratory tests.

The two types offered are well shielded, compact, rugged, economical, and operate at temperatures up to 130°C. All units feature low bilateral VSWR, 1.20 (maximum), negligible RF leakage, and anti-backlash construction.

The attenuating vane in type 1 (MA-527-A and MA-670) is controlled by a micrometer mounted atop the control knob to assure anti-backlash operation combined with extremely accurate reproducible calibration. In type 2 (MA-580-A and MA-587) the attenuating vane is controlled by a spring-loaded knob driven by a tuner with a locking device for locking at any desired value of attenuation.

These single vane "guillotine" type attenuators are suitable for laboratory use where the calibration of filters, directional couplers, attenuators, and other lossy devices must be performed. They are also useful in the "field" where permanent dependable installation is necessary.

Circle Reader Service Card 139

— m w j —

NANOSECOND PULSE AND RF AMPLIFIERS OFFERED BY RHG ELECTRONICS

A series of wide-band pulse and radio frequency amplifiers that feature nanosecond rise times, negligible ringing, no overshoot and self-contained power supplies, have been introduced by RHG Electronics Laboratory, Inc., Farmingdale, N.Y.

(Continued on page 138)

ANTENNA PEDESTAL SCR 584-MP 61B

Full azimuth and elevation sweeps 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ, 9 degrees per second squared EL, 4 degrees per second squared. Angle slowing rate: AZ 20 degrees per sec. EL 10 degrees per sec. Can mount up to a 20 ft. dish. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control amplifiers. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar system, radio astronomy, any project requiring accurate response in elevation and azimuth.

Complete description in McGraw-Hill Radiation Laboratory Series, Volume 1, page 284 and page 209, and Volume 26, page 233.

MIT MODEL 9 PULSER 1 MEGAWATT-HARD TUBE

Output pulse power 25 KV at 40 amp. Max. duty ratio: 002. Uses 6C21 pulse tube. Pulse duration .25 to 2 microsec. Input 115 volts 60 cycle AC. Includes power supply in separate cabinet and driver. Fully guaranteed as new condition. Full Desc. MIT. Rad. Lab. Series "Pulse Generators."

500 KW PULSER

5C22 Hydrogen Thyatron Modulator. 22KV at 28 Amps. W/HV & Fil supplies. 3 pulse length rep rates: 2.25 μ sec 300 pps. 1.75 μ sec 550 pps. .4 μ sec 2500 pps. 115V 60 cy AC input.

MIT MODEL 3 PULSER

Output: 144kw (12kv at 12 amp.) Duty ratio: 001 max. Pulse duration: .5 1 and 2 micro sec. Inputs 115v 400 to 2000 cps and 24 vdc. \$325 ea. Full desc. Vol. 5 MIT Rad. Lab. series pg. 140.

1 BAND RF PKG

20KW peak 990 to 1040MC. Pulse width .7 to 1.2 micro sec. Rep rate 180 to 420 pps. input 115vac. Incl. Receiver \$1200.

225 KW X-BAND RF

4J50 Magnetron RF Generator with dummy load & Dir. Cpr. Variable rep rates. Variable power output 115V 60-cycle AC input. New. \$2400 complete.

60 MC I.F. STRIP

-95 DBM sensitivity. 130 DB gain. 1 MC & 5 MC band widths. Mfg. Texas Instruments. \$125 each w/tubes.

SCR 584 RADARS AUTOMATIC TRACKING RADAR

Our 584s in like new condition, ready to go, and in stock for immediate delivery. Ideal for research and development, airway control, GCA, missile tracking, balloon tracking, weather forecasting, antiaircraft defense tactical air support. Write us. Fully Desc. MIT Rad. Lab. Series, Vol 1, pps. 207-210, 228, 284-286.

AN/TPS-ID RADAR

500kw. 1220-1359 mcs. 160 nautical miles search range P.P.I. and A Scopes. MTI, thyatron mod. 5J26 magnetron. Like new. Complete system incl. spare parts and gas generator field supply.

AN/TPS-10D HEIGHT FINDER

250 KW X-Band. 60 & 120 mile ranges to 60,000 feet. Complete.

AN/AP5-15B 3 CM RADAR

Airborne radar. 40kw output using 725A magnetron. Model 3 pulser. 30 in. parabola stabilized antenna. PPI scope. Complete system. \$1200 each. New.

10KW 3 CM. X BAND RADAR

Complete RF head including transmitter, receiver, modulator. Uses 2J42 magnetron. Fully described in MIT Rad. Lab. Series Vol. 1, pps. 616-625 and Vol. II, pps. 171-185 \$375. Complete X Band Radar System also avail. incl. 360-deg. antenna, PPI. syn pwr supply. Similar to \$17,000 weather radar now in use by airlines, \$750 complete.

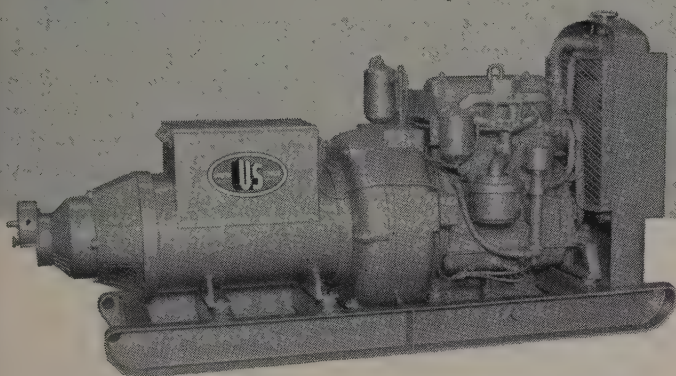
10 CM. WEATHER RADAR SYSTEM

US Navy Raytheon, 275 KW peak output S band. Rotating yoke Plan position indicator. Magnetron supplied for any S band frequency specified, incl. Weather Band. 4, 20 and 80 mile range, 360 degree azimuth scan. Sensitive rcvr using 2K28/707B and 1N21B. Supplied brand new complete with instruction books and installation drawings. Can be supplied to operate from 32VDC or 115 volts. Price \$975. Ideal for weather work. Has picked up clouds at 50 miles. Weight 488 lbs.

RADIO RESEARCH INSTRUMENT CO.
550 FIFTH AVE.,
NEW YORK
JUDSON 6-4691

POWER SURETY

OF THE
COMMUNICATIONS
INDUSTRY.....



MODEL MG10D-18

10 KW DIESEL MICRO POWER

WITH NEW "BRUSHLESS"
GENERATOR



"NO-BREAK" MICRO POWER
ENERGY IS USED...

-  at telephone central offices—carrier repeater stations.
-  on Microwave installations for communications, remote control, telemetering.
-  by public utilities for protective relaying, telemetering and load distribution.

U.S. MOTORS 10 KW DIESEL MICRO POWER functions either as a voltage stabilizer when power from the normal source is at usable, but uneven value—or as the independent power supply when there is a complete power failure. Regardless of the situation, critical communications equipment is assured a constant source of stable voltage electric power at all times. Micro Power, smoothly and with no break in required voltage, transfers the load back when commercial power is restored, at the same time continuing in its full time role of eliminating voltage droop, drop, or break.

10 KW DIESEL MICRO POWER FEATURES —

- no brushes, commutator, or slip rings to service or replace with new brushless generator
- squirrel cage motor with less than one percent slip
- conservatively rated bearings
- diodes arranged for easy access
- voltage adjusting potentiometer
- magnetic amplifier regulator mounted directly on unit
- overvoltage protection

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UNITED STATES MOTORS CORPORATION

102 West Fifth Avenue

Oshkosh, Wisconsin

FROM STOCK BROADBAND DISC BOLOMETERS

FOR PRD TYPE 627A AND
NARDA TYPE 561 MOUNTS



**5-PACK
only \$99⁰⁰**

(Package of 5 BOLOMETERS—4.5 or 8.75 ma)
SINGLE BOLOMETERS \$25.00

Features

- Gold electrodes for maximum stability
- Matched 100 — ohm Wollaston wire elements
- All units checked for power sensitivity and thoroughly stabilized.
- Low VSWR over 500 mc to 10,000 mc frequency range
- 4.5 ma bias current — SPECIFY FILMOHM TYPE MWB-450
- 8.75 ma bias current — SPECIFY FILMOHM TYPE MWB-875
- BOTH TYPES AVAILABLE FROM STOCK — IMMEDIATE DELIVERY

Ideally suited for attenuation measurement and all relative and absolute microwave power measurements, Filmohm Type MWB Bolometers are provided with alignment holes to facilitate proper assembly in standard suitable mounts. All Filmohm Type MWB Bolometers are precisely constructed to provide element resistance for optimum VSWR and efficiency. In addition, each Bolometer is precision-checked for power sensitivity, thoroughly stabilized for maximum power, and checked to ensure low VSWR over the entire 500 mc. to 10,000 mc. frequency range.

For more information, write or call today.



**FILMOHM
CORPORATION**

48 West 25th St., N.Y. 10, N.Y., WA 4-6605

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New Products

(Continued from page 136)

Models amplify maximum pulse widths from 10-1000 microseconds and provide <2 to <10 nanosecond rise times, 0.25 to 5 peak output voltages, rf bandpass of from 100 cps — 300 Mcs, 20-100 db gain, and input and output impedances of from 90-150 ohms.

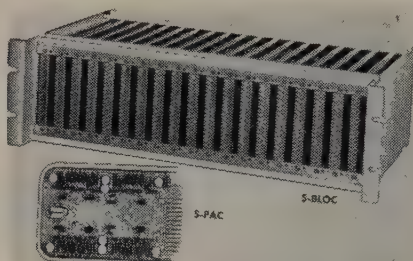
All models have front panel gain control adjustments. Units are housed in bench-top instrument cases or are available in rack-mounted versions.

Pulse amplifier systems are also available with higher pulse voltages, other impedance levels and special mechanical configurations.

Circle Reader Service Card 140

— m w j —

5-MC DIGITAL MODULES FEATURE TRANSISTOR LOGIC



Computer Control Co., Inc., Framingham, Mass., announces a complete series of low-cost high-reliability S-PAC digital plug-in packages operating in the frequency range of dc to 5 Mc.

Featuring transistor logic, the modules have high package density (e.g., four flip-flops/board) and moderate power requirements, and are particularly suited for the design of high-speed digital computers and systems.

In addition to flip-flops and other basic logic elements, the S-PAC line includes octal/decimal encoders and decoders, analog-to-digital converters, digital-to-analog ladder networks, Schmitt triggers, shift registers, and numerous special circuit boards. A complete line of 5-Mc MIL-S-PACs, designed to military specifications, is available on special order.

5-Mc S-PAC modules use glass epoxy cards (4½ inches x 7 inches), etched circuits, anodized aluminum frames, and 34-terminal connectors (solder or taper pin), and are interchangeable with existing 1-Mc S-PACs. As many as 28 modules can be housed in a single pre-wired, standard 19 inch rack-mounting S-BLOC.

Circle Reader Service Card 141

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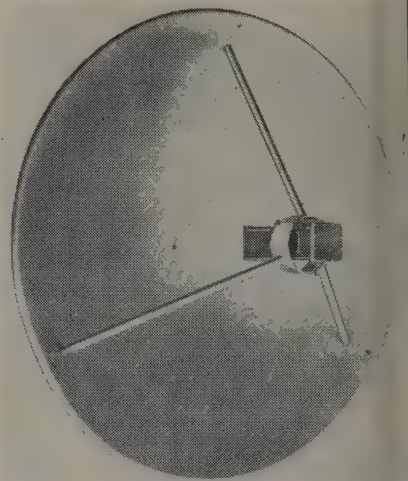
PRODELIN INTRODUCES SIX DUAL POLARIZED ANTENNAS

Prodelin, Inc., Kearny, N.J., announces six Dual Polarized Parabolic Antennas which cover the frequency ranges of 1700-1850 Mc and 1850-1990 Mc.

The latest additions to Prodelin Microwave antenna systems are available in six, eight and 10 foot size parabolic reflectors, and incorporate Spir-O-Line co-

axial cable feed lines for high efficiency ease of installation, and reliable service.

The probe excited feed horn accomplishes excitation and propagation of



two orthogonal modes. Approximately two wavelengths long at its lowest operating frequency, the horn is essentially an open-end square waveguide designed to illuminate the reflector to obtain highest efficiency. Cross talk is kept to a minimum of 40 db.

Input fittings to the feed horn adapt feed lines with 1/2 inch Spir-O-Lok connectors which include built-in gas barriers. Antenna input consists of two 10 foot lengths of 1/2 inch Prodelin Spir-O-Line, which can be terminated with matched Spir-O-Lok coupling, standard 7/8 inch EIA male connector or waveguide adaptor.

Circle Reader Service Card 142

— m w j —

1/2 INCH FIXED ATTENUATOR PROVIDES 10 DB ATTENUATION

A compact fixed attenuator providing 10 db of attenuation with only 1/2 inch insertion length is available from Mi-



crowave Components and Systems Corp. Monrovia, Cal.

the microwave journal

Designed to operate at 8.5-9.6 Gc, model No. X218 has an input VSWR of 1.15 maximum. It is for use in X-band waveguide systems or laboratory test set-ups.

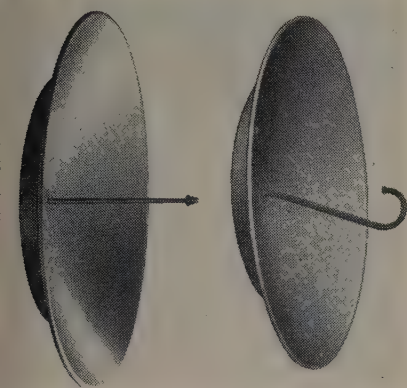
A "molded in" attenuating element, with excellent shock properties, eliminates the fragile handling necessary with conventional resistive card attenuators. Suitable for use over a broad temperature range (-55° to $+160^{\circ}\text{C}$) it also provides excellent dissipation properties, up to one watt CW.

Other models at H band (RG 51/U) and P band (RG/91/U) are also available on request.

Circle Reader Service Card 143

— m w j —

TACO DEVELOPS FIVE COMMON CARRIER MICROWAVE ANTENNAS



Extensive research and testing by Technical Appliance Corp., Sherburne, N.Y., on its "free-space" test range has resulted in development of five models of common carrier microwave antennas.

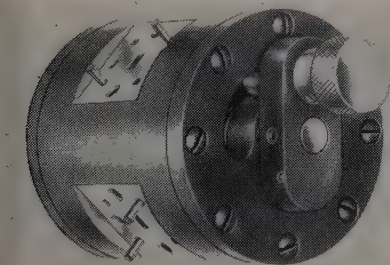
Inputs are waveguide flange selected to mate with customer requirements and bleeder ports are provided to permit pressurization of the feed. Vibration dampening is obtained by guying.

Taper feed is available with eight and 10 foot reflectors; button hook feed may be ordered with six, eight and 10 foot models. Frequency range covered by these antennas is from 3700 — 4200 Mc.

Circle Reader Service Card 144

— m w j —

TRG ANNOUNCES MECHANICAL WAVEGUIDE SWITCHES



Technical Research Group, Antenna and Microwave Department, Somerville,

December, 1961

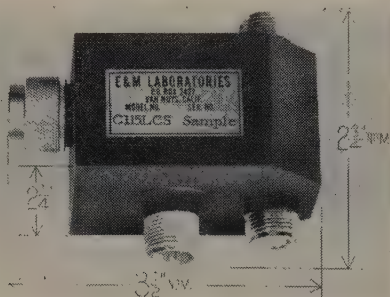
Mass., announces a complete line of three and four port mechanical waveguide switches for use in RG/96/u, RG/98/u, RG/99/u, and RG/138/u waveguides.

Switches have approximately .3 db loss over entire waveguide band, and greater than 40 db isolation between ports; VSWR is 1.15 or less. Hardened steel alignment shaft accurately sets rotor for optimum performance. Solenoid operated switches are also available.

Circle Reader Service Card 145

— m w j —

MICROWAVE COAXIAL MECHANICAL SWITCH AVAILABLE FROM E & M



E & M Laboratories, Van Nuys, Cal., announces the availability of a recently developed microwave coaxial mechanical switch. The switch has been designed to withstand the extreme environments of modern missiles.

Ruggedness for durability against shock and vibration, and capability to operate in temperatures up to $+300^{\circ}\text{F}$, have been combined with minimal size. Standard units cover the frequency range of 0 to six kMc, and switch in a nominal operating time of 10 milliseconds. The actuator requires approximately eight watts of power.

Circle Reader Service Card 146

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PAPERS

We wish to emphasize again that "the journal" is interested in receiving papers from the industry.

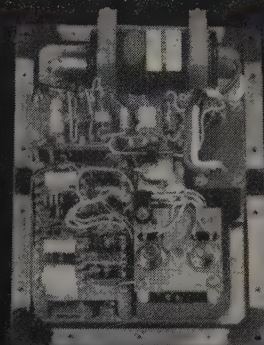
Papers can be addressed to: "the microwave journal," 1330 Beacon St., Brookline 46, Mass.

— m w j —

CHANGE OF ADDRESS

When submitting a change of address, please complete the subscription card inside the back cover of the magazine. Include the address at which you have been receiving *the microwave journal*, and allow one month for the change to become effective.

ACF MICROWAVE EQUIPMENT



X-BAND TRANSMITTER
TYPE NO. 501

COMPACT DESIGN WITH NO PERFORMANCE PENALTIES. SYSTEM-TESTED FOR OPERATIONAL SPACE VEHICLES. ENGINEERED TO MEET COMPLETE MILITARY MISSILE SPECIFICATIONS.

Frequency Range: 8900 mc to 9400 mc
Wave Guide Power Output: 1,000 Watts, peak

Duty Cycle: 0.002 (maximum)

Pulse Width: 0.45 μ seconds $\pm$ 0.1 μ seconds

Minimum Pulse Spacing: 90 μ seconds

Modulation: Pulse

Modulator: Solid State

Input Voltage: 24-30 V DC @ 1 amp.

6 V DC @ 0.45 amp.

May be operated as a free-running pulse transmitter or used with a commutator type telemetry unit capable of providing PPM triggering signals at rates up to 900 bits/sec.

Standard designs modified to meet specific requirements. Complete manufacturing and engineering resources supported by local field service. Full line of components for L, S, C or X-Band Frequencies.

ACF Beacons have qualified for more major satellite and missile programs than any other beacon.

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NEW LITERATURE

MICROWAVE CAVITY BROCHURE EMPHASIZES TRIODE CAVITY

Microwave Cavity Laboratories, Melrose Park, Ill., has released a brochure containing information which deals with standard cavities, with special emphasis on the triode cavity, series "N".

Standard cavities are primarily available in two general types: narrow tuning range and extended tuning range. The series N units tune essentially 10 per cent while the series E units can be designed to tune much greater ranges.

Design criteria of the standard MCL cavity include: small size, light weight, ruggedness and overall stability of operation. The Standard cavity units are capable of working with at least 40 other tube types where only slight cavity modifications are required. These tubes are of a similar form factor but were primarily modified by the manufacturer for particular applications.

The Standard Operating Data of the MCL cavities outlined in the brochure complies with the majority of applications.

Circle Reader Service Card 147

— m w j —

SHORT FORM CATALOG DESCRIBES BORG-WARNER TEST INSTRUMENT LINE

Borg-Warner Controls, Santa Ana, Cal., has published a short form catalog describing their expanded line of test instruments, miniature magnetic tape recorders, data reduction systems and variable reluctance transducers and accelerometers.

The line of test instruments includes vacuum tube voltmeters, VSWR indicators, volt-ohm meters, R-F power meters, precision slotted line instruments and signal generators covering HF, VHF, UHF and SHF.

Circle Reader Service Card 148

— m w j —

PERKIN OFFERS FREE "MASTER POWER SUPPLY CHART"

A "Master Power Supply Chart" containing specifications on all laboratory DC power supplies and AC line regulators is available free from the Perkin Electronics Corp., El Segundo, Cal.

The notebook-size fold-out chart is three-ring-punched. It lists such information as output, regulation, ripple, impedance, dimensions, and price.

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— m w j —

ALL SIZES

MS FLANGES

IN STOCK



THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVEGUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

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1961 NARDA CATALOG INCLUDES 600 COMPONENTS AND TEST EQUIPMENT

More than 600 items ranging in price from \$5.50 to \$9375 are listed in the 1961 catalog of The Narda Microwave Corp., Mineola, N. Y., manufacturer of components and test equipment for microwave and UHF communications systems.

The catalog is divided into sections: waveguide and coaxial attenuators, bolometers and thermistors, directional couplers, ferrite devices, ridge waveguide test equipment, through the whole range of Narda products. Another section is devoted to technical data and charts.

An index lists the items by federal stock number, alphabetically and by model number.

In addition, the catalog contains a list of both domestic and overseas representatives; information on how to order catalog items and to have Narda instruments repaired or recalibrated; information on Narda's sales engineers, and a standard waveguide data chart.

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— m w j —

HEWLETT-PACKARD PUBLISHES MICROWAVE CATALOG

A 32-page catalog of microwave instrumentation has been released by Hewlett-Packard Co., Palo Alto, Cal.

Because of the requirements of the microwave engineer, Hewlett-Packard has developed a special catalog dealing only with the generation, transmission, and measurement of microwave phenomena. For convenience in use, the contents of this catalog have been arranged by frequency range, rather than by model number as in conventional catalogs.

Designed to be educational as well as convenient to use, the first few pages briefly review the basic microwave measurements, and photographs of typical equipment set-ups for these measurements appear throughout the catalog.

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"RFI CONTROL" BROCHURE MADE AVAILABLE BY ELECTRO • INTERNATIONAL

A 4-page color brochure entitled "RFI Control" has been published by Electro International, Inc., 12-year-old RFI control firm, Annapolis, Md.

In addition to explaining how time and money can be saved by early anticipation of RFI problems, the brochure gives a comprehensive list of the Company's RFI testing equipment, engineering personnel backgrounds and corporate experience.

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— m w j —

the microwave journal

PRD RELEASES REPORT ON COAXIAL SYSTEMS MEASUREMENT
PRD Electronics, Inc., subsidiary of Harris-Intertype Corp., Brooklyn, N. Y., manufacturer of microwave and electronic test instruments, has released an 8-page PRD Report entitled "Measurement of VSWR in Coaxial Systems" by Leonard Sweet and R. A. Lebowitz.

The paper describes in detail the current methods used in obtaining standing wave measurements of microwave components, with emphasis on coaxial systems. By informative diagrams, graphs, and photographs of coaxial test equipment, this report describes the common types of coaxial lines used in systems, such as rigid air lines and solid dielectric cables. Numerous coaxial connectors, including Types N, C, BNC, HN, LC, LT, UHF, miniature and others, are also described.

In various sections of this publication, the philosophy, definition and measurement of VSWR are compared and discussed. A section on applications covers the fundamental uses of equipment commonly employed in standing wave measurements.

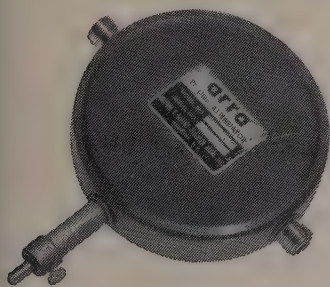
The report also covers the latest progress made in VSWR measurement. It defines the terms used and discusses new techniques for making standing wave measurements. The errors inherent in the use of a slotted section, such as residual VSWR, slope, and irregularities, are also described. A bibliography is included.

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— m w j —

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**SYLVANIA ANNOUNCES
MICROWAVE DIODE PRODUCT
GUIDE**

A new microwave diode product guide has been made available by Sylvania Electric Products Inc., a subsidiary of General Telephone & Electronics Corp., Woburn, Mass.

John Spitzer, advertising-merchandising manager of Sylvania's Semiconductor Division, said the 26-page illustrated brochure contains the electrical characteristics and performance ratings of a wide range of microwave mixer, detector, varactor, tunnel, and switching diodes.

It also features a 4-page replacement guide insert, complete listing of mechanical and environmental test procedures, and more than six pages of microwave diode applications notes, he added.

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— m w j —

**RADOME, ANTENNA TESTING
SYSTEMS DESCRIBED IN DUNN'S
BROCHURE**

Complete systems for radome and antenna testing and dielectric measurements, including production testing with laboratory accuracy, are described in an illustrated, four-page color brochure available from Dunn Engineering Corp., Cambridge, Mass., a developer-manufacturer of advanced electronic systems and inertial guidance and other missile program test instruments. The bulletin No. R1000, illustrates a typical Dunn system which can be programmed to accommodate the user's individual equipment test procedures.

Circle Reader Service Card 155

— m w j —

**SPERRY PROVIDES BROCHURE
ON HIGH-POWER PULSED TWT'S**

Sperry Electronic Tube Division, Gainesville, Fla., has announced the availability of a brochure providing free technical information on the Sperry line of high-power pulsed traveling wave tubes.

The two tubes covered by the announcement are — the STL-114 and the STC-152 — and operate in L and C bands, respectively. They are typical of a line of pulsed TWT's ranging from P through V bands.

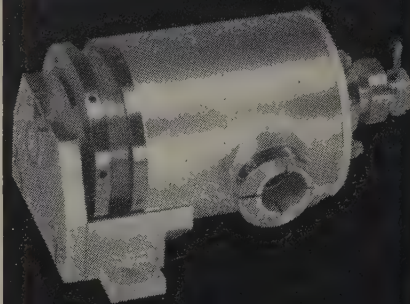
These Pulsed TWT's have compiled an impressive record of in-system experience. Such experience has proved that their resistance to shock and vibration damage, their inherent indifference to ambient conditions, and their mounting flexibility make them ideal for ground or airborne application.

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— m w j —

(Continued on page 142)

**ACF
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EQUIPMENT**



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New Literature

(Continued from page 141)

TWO-CAVITY U-BAND OSCILLATORS DESCRIBED IN SPERRY BROCHURE

Information on a new series of Two-Cavity U-Band Oscillators for Parametric Amplifier Pumping and Doppler Radar Applications is available in a brochure issued by Sperry Electronic Tube Division, Gainesville, Fla.

The brochure gives complete specifications and describes the flexibility and operating characteristics of the two-cavity oscillators. Prices are indicated and the U-Band Oscillators can be shipped in 30 days.

Circle Reader Service Card 157

— m w j —

WAVEGUIDE SUPPLEMENT TO ANTENNA CATALOG PUBLISHED BY ANDREW CORP.

Andrew Corp., Chicago, Ill., manufacturers of antenna systems, has just published a waveguide supplement to their microwave antenna catalog. The brochure gives complete electrical and mechanical characteristics of nine commonly used sizes of waveguide for use in microwave frequencies.

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— m w j —

MICROWAVE ENGINEER

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Sponge Products Div.
Canal Street,
Shelton, Conn.**

ALPHA BROCHURE DESCRIBES COLLINS' MX-106 TRANSISTORIZED CARRIER

A 12-page brochure describing Collins Radio's MX-106 transistorized carrier has been released by Alpha Corp., a division of Collins Radio Co., Dallas, Tex. The MX-106 carrier can provide up to 600 voice channels over microwave radio.

Use of all solid state components has reduced size, lowered power requirements and greatly increased reliability of the equipment. Collins' newly developed frequency generation technique, which generates carrier pulses by the use of a controlled delay line, is discussed and illustrated, as well as other circuit features of the system.

Circle Reader Service Card 159

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ELECTRIC SPECIALTY RELEASES CATALOG ON PRECISE POWER PRODUCTS

Electric Specialty Co., Stamford, Conn., a division of Electronic Specialty Co., has made available an 8-page, 2-color catalog on the ESCO line of Precise Power Products.

Bulletin 6160 details all of the ESCO standard AC-AC, AC-DC motor-alternator sets that are presently available, and gives the ratings, performance characteristics, and nomenclature of each.

In addition to photographs of many of the units, Bulletin 6160 provides explanatory diagrams of ESCO Precise-Power sets and block diagrams of their typical applications in large electrical systems.

The ESCO catalog should be of interest to designers concerned with furnishing power to computer installations, industrial-control and automation systems, telemetering and missile-guidance systems, and communications networks, or any large, complex electronic system requiring dependable, precisely-regulated, transient-free power.

Circle Reader Service Card 160

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CATALOG DESCRIBES DEUTSCH CO.'S SUBMINIATURE COAXIAL CONNECTORS

A 10 page catalog describing a new line of subminiature coaxial connectors is available from The Deutsch Co., Electronic Components Division, Banning, Cal.

In addition to the specification, performance characteristics and availability data contained in the brochure, detailed information on the proper techniques for assembling the all crimp terminated RF connector and the application tools involved is provided.

Lists of all field engineering, sales and distribution offices are also provided in this catalog-titled, "DC Connector Kit."

Circle Reader Service Card 161

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WAVEGUIDE SYSTEMS HAS BOOKLET ON VARACTOR HARMONIC

A 12-page booklet, "Varactor Harmonic Generators As Power Sources At Microwave Frequencies," is available from the Waveguide Systems Division of Microwave Associates, Inc., Burlington, Mass. Written by Mr. Marion E. Hines, research director of the Waveguide Systems Division, the booklet discusses in detail both circuits and devices which use varactor diodes for frequency multiplication. It includes specific examples of recent accomplishments at Microwave Associates, Inc.

Among the figures included in the booklet are schematic designs for an all-solid-state radio-relay communications repeater (6 kMc) and a high precision doppler radar system (both utilizing varactor harmonic generators). A variety of harmonic generators currently offered by Microwave Associates is pictured in the booklet.

Circle Reader Service Card 162

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DIELECTRIC RELEASES EXPANDED SMITH CHART IMPEDANCE PLOTTER BULLETIN

Because of the interest in the Smith Chart Plotter as a time-saving device, Dielectric Products Engineering Co., Inc., Raymond, Maine, has recently released an expanded 6-page bulletin on Smith Chart Impedance Plotters for coaxial lines.

Based on an analysis of typical questions by prospective purchasers, new material includes a discussion on phase reference, an analysis of instrument errors, and a section on measurement techniques.

Circle Reader Service Card 163

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MDL CATALOG PROVIDES DATA ON FERRITE CIRCULATORS

Catalog CR-61, available from Microwave Development Laboratories, Inc., Natick, Mass., provides data on a series of ferrite circulators available in EIA WR90 waveguide size.

The four page, color-illustrated catalog contains a discussion of how the circulator works. Applications and illustrations are included.

In addition to the detailed mechanical and electrical data set forth, a convenient guide is provided to facilitate the ordering of circulators for specific requirements.

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— m w j —

the microwave journal



Said Johann Kepler: *"The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."*

With interplanetary voyages fast becoming a reality, complete information regarding the velocity requirements for travel between planets is of vital importance. With these data available, it is possible to analyze propulsion requirements, plan ultimate system configurations, and conduct feasibility studies for any particular mission.

Lockheed Missiles & Space Company scientists have actually evolved a rapid-calculation method, utilizing a high-speed computer. This has produced literally thousands of orbits, velocity requirements, and elapsed time, for design studies of trips to and from both Mars and Venus—every tenth day from now until January, 1970.

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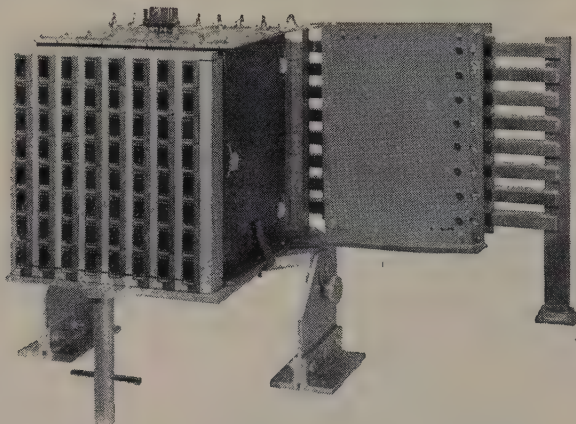
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Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS programs. Other current programs include SAINT, ADVENT and such NASA projects as OGO, OAO, ECHO, and NIMBUS.

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII
December, 1961

Opportunities in Basic Research or Development in the fields of

ELECTROMAGNETIC THEORY & ANTENNAS



■ Requirements of new and continuing projects concerned with space vehicle communications, navigation, and radar have created new openings for electromagnetic theory specialists as well as antenna engineers. The scientists and engineers of the Research and Development Division of the Hughes Aircraft Company Aerospace Group in Culver City are providing broad scientific and technical leadership to government and company funded programs on advanced airborne and space electronic systems, air to air missiles, ballistic missiles, and satellite and interplanetary communication systems. As part of this team, the Antenna Department is responsible for a diversified program of antenna research and development in the following specific areas:

- | | |
|--|---|
| <p>1. Advanced techniques for space communication and navigation.</p> <p>2. Information theory and data processing applied to antenna systems.</p> <p>3. Statistical analysis of scattering propagation.</p> | <p>4. Pattern synthesis from sources on arbitrarily curved surfaces.</p> <p>5. Aperture control by application of solid state devices.</p> <p>6. Multi-function aperture and feed capabilities.</p> |
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Immediate assignments exist for scientists and engineers of superior ability who meet the qualifications in one of the following categories:

RESEARCH ■ Advanced degrees and experience in electromagnetic theory ■ Interest in fundamental research in antennas, wave propagation, scattering theory, plasma effects on electromagnetic radiation, and solid state antennas.

DEVELOPMENT ■ Graduates in E.E. or Physics or extensive experience in lieu of degree. ■ Minimum of three years of professional experience in monopulse and conical lobing antennas in reflector and array configurations, electronically scanned arrays, inflatable and erectable antennas, shaped beam arrays from curved surfaces and signal processing antenna systems.

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A DEVELOPMENT BY THE SCIENTISTS AT AMHERST LABORATORIES**

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Advance the state-of-the-art of microwave space vehicle transmitters by increasing performance, reducing size, reducing weight and increasing reliability.

The time was June 1960. One year later, these objectives had been reached
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The result: a solid-state transmitter applicable for satellite use,
operating within the S-band, about half the size of a carton of cigarettes,
and with a life expectancy of two years.

This significant achievement is representative of many challenges currently
being met by the scientists at Amherst Laboratories.

*PAPER ON REQUEST: The paper which explains the new techniques employed in
development of the new microwave Solid-State Transmitter authored by W. J. Maciag
is available to engineers and scientists on request. Write for the paper entitled
"Solid State, S-band Single Side Band Suppressed Carrier Transmitter"*

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MANAGEMENT CONSULTING IN THE ELECTRONICS INDUSTRY

By HERBERT K. ALLARD

Electronic companies pose special problems for the management consultant. The industry is characterized by many small fast growing companies that seem to sprout up like mushrooms or sometimes wink out like stars. These firms start out as highly sophisticated job shops strongly dominated by engineering and scientific personnel. Some of these people may be fortunately gifted with the skills of business management. Other technical people may well reflect the root problem of American small business: the top men either lack overall management ability or they tend to ignore, under-rate, and be disinterested in other phases of operations. In addition, the electronics industry is heavily subsidized by government money. Success for some companies may have come much too easily due to the research and development dole. Not so, for example, with the textile industry. In New England, many textile companies have left for the South or have gone out of business. Foreign competition is fierce. The successful textile managers who have survived this economic contraction are extremely apt.

A day of reckoning for electronic companies may be at hand. Every issue of the trade journals reveals mergers, acquisitions, underwritings, and loans from equity capital houses. Part of these financial manipulations may be due to the hard pressure of increasing competition which has resulted in the lowering of profits and in some cases, losses. For example, one common reason for an unhappy P & L statement is the simple lack of accurate direct labor and direct material costs upon which can be based realistic selling prices.

In several instances, the writer was amazed to discover during a cost analysis that one company did not realize



that its products were being sold off the shelf at a loss. In another situation, a company had landed a sub-contract by unwittingly under-bidding through failure to put together a complete parts list. In another company, the estimated direct costs just about equalled the actual direct costs; and it looked like a profitable job except that the equipment didn't work. The equipment was returned to the manufacturer whose net loss for the year was largely reflected in the unrecoverable costs for that one job. Management had no right to quote on this job at all.

One of the best ways to make a contract profitable is to start off with an up-to-date, finalized set of drawings along with a completely accurate parts list. The parts list can be broken down into various classifications: mechanical and electrical items, raw materials, purchased parts, hardware, items to be manufactured in the shop.

HERBERT K. ALLARD received a BS degree from Harvard College in 1946 and an MBA from the Harvard Graduate School of Business Administration in 1951. Since 1958 he has served as president of H. K. Allard & Associates, Cambridge, Mass., a firm which has completed client assignments principally in the electro-mechanical and electronic industries.



Previously, he served as production manager for General Electric Laboratories, Cambridge, Mass., and prior to that was a methods analyst at General Electric Co., Louisville, Ky. Mr. Allard is a professional industrial engineer in the Commonwealth of Massachusetts and a member of the IRE

and items to be sub-contracted. Such classification will prove a great help in breaking down costs, in scheduling work to be done, and in pin-pointing troublesome deliveries from vendors. Of course, even if materials and parts are carefully tabulated, then the estimate of direct labor many times can be way out of line. In the electronics industry where things are often made for the first time, it is understandably difficult to predict accurately the hours for assembly. However, in case of a wide variance in labor hours, the actual figures should be immediately compared to the estimated figures. It's not a question of persecuting the person responsible for the estimate; rather it's good business to focus on what went wrong in order to take corrective action for the next job. This attitude saves money.

In still another company, top management decided that they desperately needed a certain type of CPFF research and development government contract. The company was eminently qualified to bid because their engineers and facilities were excellent. To obtain the contract, they compiled a meticulously accurate and realistic quote. But, fearing that some larger and nationally recognized competitors would get the desired contract, they drastically whittled down the quote. They rationalized the reduction on the cliché that being knowledgeable in this scientific area would advance the company into the state of the art. The company got the contract; and the next nearest competitor was six figures higher. Naturally, the contract ran out of funds and was far behind schedule. The company requested and fortunately received additional funds and an extension of time. Of course, the fixed fee percentage was at least halved. Worse still, the government agency was furious and threatened to cut off the company from future contracts.

Another problem contributing to low profits is a surfeit of overhead expenses brought about, in some cases, by empire building, Machiavellian or just plain unrestrained and innocent enthusiasm. For example, one currently hot topic of discussion is electronic data processing. Computers seem to hold a special attraction for electronic engineers. The computer is studied for the results obtained but not necessarily for the costs involved. The philosophy is akin to the Great American Horsepower race. Perhaps a Volkswagen would provide better all round transportation.

The writer can recall one electronics company — employing less than 300 people — who hired a recent graduate from a well known Eastern business school located on the banks of a river named after a famous English king. This fellow was intensely interested in convincing management that their record keeping would best be handled by IBM's RAMAC 305. It seems to me that one of these half human machines would be just the ticket for a small number of corporate brontosauri or would be ideally suited for global military logistics problems and for computations involving the number of light years to Uranus.

Just take the yearly rental costs of the RAMAC 305 plus the salaries of the people needed to operate the system and subtract from this total the similar costs of a more modest IBM system designed for a smaller company. The dollar difference would be a nifty addition to net profit. Of course, the engineering rebuttal follows in this manner: We need a computer to solve our mathe-

matical problems; and as long as we have a computer, we can more fully automate our record keeping and do it faster.

So, every conceivable bit of raw data is fed into the machine to justify its existence. It must be gratifying to discover how many employees drink coffee with his or her left hand. It must be interesting to discover — on the basis of solving mathematical problems — how much down time is left on the machine. Would it not be better to scout around town and make a deal to share another company's computer?

How can small companies honestly begin to automate their record keeping without having a monster created? First, the chances are if the records can be kept manually, then stick to the manual system. Make sure that the present manual system is efficiently operating and actually works. Consider other manual systems to take care of an increasing volume of work. Always question if you really need to use higher speed — and more costly — equipment. Find out exactly how much it costs now to run the department and then carefully consider how much money can be saved in automation. Go slow and possibly rent only one or two pieces of equipment in order to feel your way along. Don't go whole hog and accept the A-OK oily blandishments of the equipment salesman whose technical acumen may be excellent but whose objectivity is certainly questionable. After all, he's got mouths to feed and booties to buy. Perhaps one good angle is to submit the overall problem to an independent data processing consulting firm and then farm out your record processing as a starter. Farming out this type of work has an advantage in that a company is forced to submit accurate records. The raw data must be perfect. Furthermore, the costs of doing the work on the outside will be in black and white and will constitute a sound base for a decision to rent what equipment at a later date.

Another interesting example concerned a large electronic company that had installed some EDP equipment essentially for the purpose of inventory control. The system failed. Oddly enough, the actual inventory in stock was beautifully organized, a model of neatness and efficiency, and run by a highly competent employee. The raw data which he submitted regularly for processing was somehow bungled by the front office. Consequently, what went into the EDP system came out drastically at odds ends with the twice-a-year physical inventory check. The inventory control manager howled with frustration; and the comptroller was foaming at the mouth to throw out the equipment. It took almost a year to straighten out the mess. The money wasted in this instance did not have a great effect on the net profit but it was wasted.

One of the main problems for the management consultant in the electronics industry is to convince and persuade top management of the need to look more carefully at the Big Picture, the need for an occasional change in corporate direction, and the value of objective and business-like advice and counsel from a disinterested party. Of course, calling in a management consultant doesn't mean at all that one's company is in danger of bankruptcy and dissolution. A consultant may serve to corroborate or modify management thinking and decisions in a profitable venture. After all, how can one honestly criticize and improve upon success?

The writer did a study for a fast moving, exotic, and

highly profitable electronics company. The problem seemed to be not now but later. Shrewd and practical engineers organized the company and were absolutely responsible for its amazing success. They were also vital to its continued rapid rate of expansion. However, the engineers dictated the corporate philosophies with an iron hand. The Purchasing department was nothing more than an economic eunuch. It bought strictly to the sole recommendation of the specifications. There was little opportunity to buy for price and delivery. By the same token, the Quality Control department was dominated by the engineers who set the parameters of inspection. The Quality Control department was bulging with people checking the checkers. Again, by the same token, the Planning department was huge. Actually, the planners were expeditors. Scheduling production runs was a function of the engineers. They accepted all orders no matter how small or non sequitur and acquiesced to almost any delivery request. It was a terrible headache for the Production manager. In addition, the company had just successfully completed a very difficult engineering contract, had made money, and had delivered critical military equipment on time. The superfluous engineers, now no longer needed after a massive technical breakthrough, were assigned to company sponsored research and development projects. In general, it takes about five years to bring these projects into fruition. From a marketing standpoint, these projects didn't appear to be too hot. Overall, the situation was not critical. The danger signs were present; and in several years or less, the company might be saddled with some serious problems.

On the other hand, if a company really is in serious trouble, it is much easier for the consultant to pull the white rabbit from the top hat and to come up with a dramatic answer to Why. Sometimes, it's quite simple to spot the source of trouble. The difficult task is to prove the diagnosis with the time allotted . . . which usually isn't too much . . . and to do so without overly irritating the people who requested the help. But, it may be better to tell the truth even though frankness in a report can have the temporary effect of a bomb.

This sort of discussion must not imply a continued and heated battle between top management and the consultant. On the contrary, after the job is finished, the consultant usually maintains a strong personal and social relationship in addition to some hard won and mutual respect. In a general sense, the worth of a consultant's work can only be measured by the return which his client gets from his investment. The easiest way to please a client is to streamline his operations on a cost reduction basis so that the consultant's fees are sensationally low compared to the total savings. The writer, for example, has reduced an inventory requirement from \$70,000 to \$7,000 merely by feeling that one raw material purchasing philosophy had the ring of a counterfeit coin. In another situation, the writer eliminated \$30,000 in spoiled work per year. In both cases, the purpose of the consultant was *not* to investigate direct materials or inspection. Yet, a payback philosophy may not always be the answer. Sometimes a prevention of mistakes is less costly than correcting them.

In the electronics industry, the effectiveness of a con-

sultant may be measured in an additional manner. For example, consider a company that has gone public and is listed on the Over-The-Counter Market. In the last analysis, the profit margin is the most important single method of evaluating a company. Electronic securities on the open market are highly sensitive to fluctuations in earnings. A modest increase in profit may result in a sensational rise in the value of the securities and in the capital gain possibilities for the majority stock holders. Furthermore, if the company is pursuing a policy of expansion and survival by acquisitions, then its bargaining position is obviously better in swapping stock and in attracting the smaller company to merge or be bought out.

How should top management choose a consultant? It's hard to say; and it depends upon the problem. For example, many of the large accounting firms with offices in New York have organized their own management services groups. These firms may be more experienced in general paper work problems. Or, large general management consulting firms are usually proficient in mapping out corporate plans and strategy. For the small company, these firms are also pretty expensive. Some of the fees are directly proportional to the weight of the report which could be summed up in a few unpolished phrases like: Stand pat and do nothing . . . You need a new vice president and Joe has got to go . . . The plant is a sewer.

Many of the smaller consulting firms specialize in areas like quality control, warehousing, plant layout, etc. Other small firms concentrate on industries like publishing or shoes. A great many firms of all sizes belong to management consulting associations. Membership is sort of tacit approval of competence. Yet, many non-member firms are equally competent. These firms may not feel that the large association fees are worth the feeling of togetherness. Furthermore, a certain amount of purposeful exclusivity exists in the associations.

Perhaps the best way to choose a consultant is to depend upon your own quick judgment and ability to size up the man. If you like him, hire him. Of course, note his experience and education. Don't rely solely on references because the toughest person with whom the consultant must deal is the head man. Every consultant has experienced at least one job that didn't work out too well because the president kept changing his mind during the job. With a big consulting firm, if the job goes sour the consultant in the plant is a scapegoat who can be switched to placate the owner. With a small consulting firm, the chief consultant is the sum and substance of the business; and there's no room to turn around if things get sticky. Consequently, members of the small firm, being more acutely aware of this problem, generally work harder and longer, have a bigger approach to the total picture, and tend to be more frank and honest. In addition, pick a local firm within perhaps a radius of 300 miles unless you seek a specialist. Consultants can run but they can't hide. Referrals are bread and butter. Also, beware the salesman who clinches the job. Will he be the same man who does the job? Usually not. Finally, watch out for hiring a consulting firm on the basis of a high quality partner on the job. You may get a neophyte trainee.

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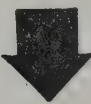
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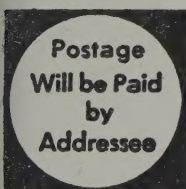
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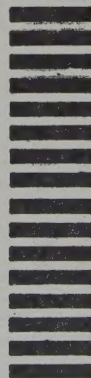
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